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NET PRIMARY PRODUCTION OF SPARTINA AND SPECIES DIVERSITY OF ASSOCIATED MACROINVERTEBRATES OF A SEMI-IMPOUNDED SALT MARSH

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Larry Alan Chynoweth, MS
Department of Biological Sciences
Florida Technological University
Orlando, Florida

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Introduction

Historically, salt marshes, dominated by cordgrasses (Spartina sp.), were found in great abundance on the Atlantic coast of the United States from Maine to the Keys of Florida. Many of these marshes have disappeared owing to reclaimation programs associated with mosquito control or the expansion of domestic, agricultural, and industrial sites (Provost, 1973; Teal and Teal, 1969).

States in the coastal zone have recognized the importance of the estuarine and salt marsh areas and have restricted or forbidden further abuse of these systems (Wass and Wright, 1969). Recently, emphasis has shifted from exploitation of salt marshes to research into the structure and function of these ecosystems (Table 1). The importance of salt marshes and the similar estuarine habitats has been pointed out by Odum (1961) and others. Generally, salt marshes furnish detritus for intercoastal and offshore nutrient cycling, nursery areas for developing aquatic organisms, erosion control, and aesthetic value (Odum, 1960, 1971; Wass and Wright, 1969; and Provost 1969). Concern on the part of the National Aeronautics and Space Administration for preservation and natural integrity of salt marshes on and near the Kennedy Space Center (KSC) prompted the work reported on in this thesis.

This study was designed to investigate selected attributes of a semi-impounded salt marsh. Variables chosen to describe the structure and function of the salt marsh were plant standing crop

biomass, net primary production, energy content of the primary producers, and species diversity of associated macroinvertebrates.

Table 1. Author, date of publication, and subject matter of some of the most recent literature on energetics and related phenonmena relative to salt marsh ecosystems.

Author(s)	Date	Invertebrates	Primary Production	Trophic Dynamics	Species Composition	Decomposition	Location
Adams	1963				X		U.S.
Boyd	1971		X				U.S.
Burkholder & Bornside	1957					X	U.S.
Cameron	1972	X	X	X	X		U.S.
Chapman	1960		X	X			U.S.
Clarke & Hannon	1967		X				For.
Cooper	1969		X				U.S.
Crichton	1967	X		X			U.S.
Davis	1940				X		U.S.
Davis	1942				X		U.S.
Davis	1943				X		U.S.
Davis & Gray	1966	X			X		U.S.
Duff & Teal	1965		X				Both
Eleuterius	1972		X		X		U.S.
Foster	1968		X		X		U.S.
Gabriel & de la Cruz	1974		X		X		U.S.
Gessner & Goos	1973					X	U.S.
Gosselink & Kirby	1974					X	U.S.
Kale	1965	X		X		X	U.S.
Keefe	1972		X		X	X	U.S.
Keefe & Boynton	1973		X				U.S.
Kuenzler	1959	X		X			U.S.
Kuenzler	1961	X		X			U.S.
Lytle	1969		X		X		U.S.
MacDonald	1969	X			X		U.S.

Table 1. Continued.

Author(s)	Date	Invertebrates	Primary Production	Trophic Dynamics	Species Composition	Decomposition	Location
Mann	1972		X			X	For.
Marples	1966	X		X			U.S.
Miller & Egler	1950				X		U.S.
Morgan	1961		X				U.S.
Niering	1961				X		U.S.
Nixon & Oviatt	1973	X	X	X	X	X	U.S.
Odum	1961		X	X	X		U.S.
Odum & de la Cruz	1964					X	U.S.
Odum & de la Cruz	1967			X		X	U.S.
Odum & Fanning	1973		X	X			U.S.
Odum & Kuenzler	1963			X			U.S.
Odum & Smalley	1959	X				X	U.S.
Paviour-Smith	1956		X	X			For.
Payne	1972			X			For.
Pomeroy	1959		X				U.S.
Purer	1942				X		U.S.
Ranwell	1964			X	X		For.
Ranwell	1973		X		X		For.
Redfield	1972			X	X		U.S.
Reimold	1972		X	X	X		U.S.
Smalley	1958	X	X	X			U.S.
Smalley	1959	X		X			U.S.
Smalley	1960	X		X			U.S.
Squiers & Good	1974		X	X	X		U.S.
Stroud & Cooper	1969		X		X		U.S.
Teal	1958	X			X		U.S.
Teal	1959		X	X			U.S.

Table 1. Continued.

Author(s)	Date	Invertebrates	Primary Production	Trophic Dynamics	Species Composition	Decomposition	Location
Teal	1962	X	X	X	X	X	U.S.
Teal & Kanwisher	1961		X			X	U.S.
Teal & Kanwisher	1970			X			U.S.
Teal & Teal	1969			X	X		U.S.
Udell et al.	1969		X		X		U.S.
Waits	1967		X		X		U.S.
Wass & Wright	1969	X	X	X	X	X	U.S.
Williams & Murdoch	1966		X		X		U.S.
Williams & Murdoch	1969			X		X	U.S.
Williams & Murdoch	1972		X				U.S.
Wolf et al.	1972	X					U.S.
Woodhouse & Seneca	1974		X				U.S.

Literature Review

Primary Production

Primary production is a fundamental process characteristic of all ecosystems and is defined by Odum (1971) as the rate at which radiant energy is stored by photosynthetic organisms (chiefly green plants) in the form of organic substances to be utilized in metabolism. Net primary production (NPP) is the rate of storage of organic matter in plant tissue in excess of that utilized by the plant for respiration. Thus, gross primary production (GPP) is equal to NPP plus the cost of respiration.

Net primary production has been estimated by many methods in terrestrial ecosystems. Milner and Hughes (1968) described techniques for the study of primary production in grassland ecosystems. Standing crop biomass is one of the most widely used methods of estimating net primary production in herbaceous vegetation (Malone, 1968). Boyd (1971), Wallentinus (1973), Keefe and Boynton (1973), Gabriel and de la Cruz (1974), Nixon and Oviatt (1973), and Teal (1962) have used this method in studies of salt marshes.

At least five different methods of estimating net primary production in terrestrial or semi-terrestrial situations are based on use of standing crop biomass. Milner and Hughes (1968) described a method whereby differences between sequential samples of living standing crop biomass are summed to estimate net primary production. A deficiency of this method is that it completely ignores dead or dying

material (Wiegert and Evans, 1964).

Wiegert and Evans (1964) estimated the rate of disappearance of dead material. Accordingly, their values for net primary production were based on differences between living standing crop biomass plus the current dead material. A third method, similar to that of Wiegert and Evans (1964), was reported by Lomniki et al. (1968) in which the rate of disappearance of dead material is assumed to be zero when the period between samplings is one month or less. Both the Wiegert and Evans (1964) and the Lomniki et al. (1968) methods were developed for use in terrestrial ecosystems and utilize the paired-plot routine. Wallentinus (1973) used both methods in studies of oceanside grasslands; however, he developed a hybrid between the methods of Wiegert and Evans (1964) and Lomniki et al. (1968) based on a single plot. His modification avoids the assumptions of the other methods, i.e., (1) disappearance rates from paired plots are equal, and (2) that the species composition and biomass of the dead material are identical on the paired plots. Wallentinus (1973) assumed that there was no dead material added to the plot during the sampling intervals and no disappearance of current dead material during the sampling interval.

Another harvest technique for estimating primary production was discussed by Williams and Murdoch (1969). One set of samples was taken at the height of the growing season and only the living material was collected. Estimates of dead material removed or which died during the interval between the beginning of the growing season and the time of harvest were made from the number of leaf scars and

damaged leaves present on the living material. Calculation of production was carried out with the weight of presently harvested material plus the estimate of the material removed prior to harvest by death or consumption.

Malone (1968) indicated that calculations of net primary production from single harvest methods, as exemplified by Williams and Murdoch (1969), contained considerable error. This error occurs most commonly in a community estimate of net primary production if the phenology of the plants is not similar. Peak standing crops of plants may occur at different times of the growing season; therefore, sampling at only one time of the year generates error from the omission of some of the peak standing crops of the earlier or later maturing forms.

High primary production rates of marsh vegetation compared with other communities is well documented (Odum, 1961, 1971). According to Keefe (1971) this may be attributed to several factors: (1) length of the growing season, (2) vertical orientation of the leaves, (3) an abundant soil water, (4) high nutrient content of the marsh soil, and (5) high concentrations of organic colloids in the marsh soil. Primary production of salt marshes ranges between 800-4000 $g \cdot m^{-2} \cdot yr^{-1}$ as compared to 10-250 and 150-1500 $g \cdot m^{-2} \cdot yr^{-1}$ for desert scrub and temporate grassland ecosystems respectively (Whittaker, 1970).

As discussed separately by Good (1965), Keefe and Boynton (1973), Stroud and Cooper (1968), Williams and Murdoch (1969), Smalley (1959), Phleger (1971), Woodhouse and Seneca (1974), Keefe (1972), Teal (1962),

Redfield (1972), Hoese (1967), Wass and Wright (1969) and Miller and Egler (1950), production and species composition in a salt marsh may vary significantly because of changes in salinity (owing to rainfall), tidal action (owing to periods of inundation due to low elevation and depth of water), and latitude (which affects the average temperature and the amount of incident solar radiation).

Odum (1961), Teal and Teal (1969), Odum and de la Cruz (1967, Cooper (1969), and Williams and Murdoch (1969) pointed out that the fertility of estuaries and their adjacent alluvial marshes are important to man and other animals in the oceans and estuaries owing to the nutrients furnished for immature marine organisms. Odum (1961) cautioned against misuse of marshland and stressed that these lands must be utilized in their natural productive state and not as spoil lands.

Energetics

Lindeman's benchmark study (1942) of energy flow established the trophic-dynamic approach to ecology. Numerous theories have been developed to explain the dynamic nature of energy in ecosystems (Olson, 1963; Margalef, 1963; Petrusewicz, 1967; Wiegert, 1968; Odum, 1960; Wiegert and Owen, 1971). Recent studies concerning energy flow from one trophic level to another include Odum (1957), Menhinick (1967), Van Hook (1971), Golley and Gentry (1966), Bernard (1974), Wiegert and Evans (1964), Odum (1960), Malone (1969), and Good (1965).

Odum (1961), Keefe (1972), Teal (1962), and Burkholder and Bornside (1957) discussed the mechanisms at work in the productivity

and energetics of marshes. Keefe (1972), Teal (1962), and Burkholder and Bornside (1957) stated that the salt marsh ecosystem consists of two governing energy systems: (1) one in which energy is derived from the primary producers by direct grazing and (2) one in which energy is derived from detrital by-products of the primary producers. The detrital foodchain based on bacterial transformation of the primary producers is responsible for the bulk of the energy flow through the salt marsh ecosystem. Odum (1961) broke this system into three distinct producer groups for Sapelo Island, Georgia. These are the cord-grass marshes lying close to the estuaries, the "mud algae" inhabiting intertidal sediments, and the phytoplankton. Teal (1962) stated that two-thirds to three-fourths of the primary production is accounted for by Spartina while Pomeroy (1959), Ragotskie (1959) and Schelski and Odum (1961) indicated that algae account for the remaining fraction.

The common denominator of energetics of an ecosystem is the calorie or gram-calorie (Paine, 1971), a precisely defined and measured physical unit (Phillipson, 1966). Golley (1959) and Cummins (1967) have furnished tables of caloric equivalents for selected biological material. Many terrestrial and aquatic studies have expressed productivity data in terms of caloric values Boyd, 1971; Van Hook, 1971; Singh and Yadava, 1973; and Menhinick, 1967). Salt marsh ecosystem studies which express net primary production and energy flow as $gcal \cdot m^{-2} \cdot yr^{-1}$ include Teal (1962), Teal and Kanwisher (1970), Squiers and Good (1974), Gabriel and de la Cruz (1974), and Kuenzler (1961).

Methodology, instrumentation, error analysis and application of calorimetry to ecological problems have been reviewed by Paine (1971). Energy determinations are usually based on bomb calorimetry. The Parr manual (1968) provided mechanical descriptions of some of the newer innovations in calorimetry including adiabatic and non-adiabatic, macro, micro, and seimimicro oxygen bombs, and peroxide bombs. Equations for calculations of caloric values were also discussed.

A versatile, inexpensive, and accurate microbomb calorimeter was developed by Phillipson (1964) to handle samples in the size range 5-100 mg. Paine (1971) pointed out that the Phillipson type calorimeter has two main advantages over the water jacket (adiabatic) types: (1) reduction in combustion time, and (2) reduced sample size (optimal sample size is 10-15 mg). Previously cited papers, in which caloric values for net primary production are given, mention employment of either Phillipson (1964) or Parr (1968) calorimeters or caloric equivalents.

Long (1934) and Golley (1961) indicated that there may be substantial differences in caloric values between parts of plants such as between seeds, leaves, stems, and roots. These differences are based on changes in concentrations of the basic organic makeup (i.e., lipids, proteins, carbohydrates) within different areas of the plant's anatomy. Golley (1961) also found variation in caloric content between vegetation from different ecological communities and suggested that direct determination of energy content should be made when studying energy flow through a natural system. Furthermore,

Singh and Yadava (1973) found seasonal differences and correlated them with the rainy, cool, and hot portions of India's seasons. Likewise, Van Hook (1971) found that caloric values may differ from season to season for the same plants. In contrast, Squiers and Good (1974) showed that although some seasonal variation occurred for caloric values based on dry weight, values based on an ash-free dry weight varied little from season to season. Malone (1968) identified variation in caloric content of identical plant species from one year to another at the same season.

Because biological organisms consist of organic substances (i.e., protein, lipids, and carbohydrates), caloric values will generally fall within the range of glucose (3.74 cal/g), cellulose (4.18 cal/g), and those of fatty acids or oils (9.37 cal/g) (Paine, 1971). All the calculated caloric values reported in the literature fall within these limits, according to Keefe (1971).

Macroinvertebrates

Primary consumers are energetically dependent on the products of primary production within the ecosystem. Although direct consumption by consumers utilizes little (7-9%) of the available resources in the ecosystem and especially in the salt marsh (Teal, 1962), they nevertheless contribute to and affect the homeostatic integrity of that system (Van Hook, 1971). Studies concerning animal species composition, energetics, and diversity in terrestrial and freshwater systems have been abundant (Wiegert, 1974; Hurd and Wolf, 1974; Muma, 1973; Hurst, 1970; Van Hook, 1971; Menhinick, 1964, and 1967; MacKay and Kalff, 1969; MacArthur, 1965). A few such

studies concerned salt marshes only (Kale, 1965, Nixon and Oviatt, 1973; Cameron, 1972; Teal, 1962; Kuenzler, 1961; Smalley, 1958, 1959; Marples, 1966; Margalef, 1956; Luxton, 1964a, 1964b, 1967a, 1967b).

Noteworthy is Teal's (1962) study which described energy flow between trophic levels in a salt marsh on Sapelo Island, Georgia. He attempted to trace the energy flow beginning with the primary producers through the herbivores and saprovores; however, few data were provided on carnivorous invertebrates. No information theoretical measures of species diversity were used to relate the stablility of the different trophic levels to one another or associated environmental conditions. Similar treatment was given the invertebrates in studies by Smalley (1958, 1959); Nixon and Oviatt (1973); Luxton (1964a, 1964b, 1967a, 1967b); Kuenzler (1961); Van Hook (1971) and Muma (1973). These studies concerned the consumption rates of herbivores, or other trophic groups, their density and biomass relationships in correlation with physical and biological components of their environments. Various sampling techniques were described in those studies.

Sampling procedures must be designed to collect particular kinds of invertebrates. Teal (1962) described several techniques for sampling invertebrates of a salt marsh. Van Hook (1971), Harrel and Davis (1965), Dietrick (1961), Barrett (1968), and Hurst (1970) have described sampling techniques for invertebrates (arthropods) which utilize a vacuum suction sampler. Hurst (1970) compared sweep netting and suction sampling and concluded that the number of invertebrates collected by the sweep net method exceeded that of the suction sampler,

but the variety (diversity) of organisms collected by the suction method was greater.

Species Diversity

Odum (1971) recognized the importance of intra-and inter-specific interactions in invertebrate populations and the information which these interactions may impart to the investigator. He indicated that species diversity indices may further elucidate organismic functions or their importance within the community. Because the number of individuals and kinds of species may be affected by stresses on the environment, species diversity measurements may be used as indicators of change within the ecosystem. Freshwater studies such as those of Wilhm and Doris (1966), MacKay and Kalff (1969), and terrestrial and marsh studies of Menhinick (1964, 1967), Wiegert (1974), and Cameron (1972), used these relationships to monitor or delineate differences among and changes in environmental conditions of habitats. Cameron (1972) found seasonal patterns of diversity among trophic levels to be highly correlated with their respective resource bases (e.g., primary production, litter accumulation, and prey populations). Wiegert (1974) used species diversity, equitability, and the coefficient of similarity, to demonstrate invertebrates inhabiting litter of three abandoned old fields differed significantly from one another in the types of organisms present, the number of species, and the number of organisms per species.

A number of different indices of community diversity exist (Williams, 1964; Menhinick, 1964). Early studies used the number

of species per sample as an index of species diversity. This approach failed to distinguish between samples in which relative abundance of the different species was unequal. Therefore, more recently introduced diversity indices have been based on the numbers of species per sample and their relative abundance (Dickman, 1968). Lloyd et al. (1968) discussed two commonly used indices of diversity based on community organization. These are the Shannon (H') and the Brillouin (H) indices. A third index (Simpson) which measures dominance was used by Cameron (1972). All three types of species diversity indices relied on the premise that the information content of a community may be expressed as the probability with which the species of the next individual sampled at random from the community can be predicted (Cameron, 1972).

There are a number of components of diversity indices which respond to geographical, developmental, and physical fluctuations in the environment (Odum, 1971). Indices must incorporate both the number of species (richness) and the distribution of individuals within species (evenness or equitability). Therefore, communities with identical numbers of species may differ in distribution of individuals among the species and thus diversity would differ.

Of the many species indices available, the Shannon-Weaver (Shannon and Weaver, 1949) and the Brillouin (Brillouin, 1962) are the most commonly used (Odum, 1971). The Shannon measure (H') is applicable when one assumes that the collection of species is a random sample from a larger parent population. It also assumes that all species have been represented in the collection and that the

parent population species are distributed randomly. The Brillouin index (H), on the other hand, is used when one assumes that the collection is from a finite population in which all members can be identified and counted. No assumption of the collection being one from a randomly distributed population is necessary in using this method.

Odum (1971) recognized the fact that, in general, diversity increases with a decrease in the ecological turnover rate; tends to be low in physically controlled ecosystems; tends to be high in biologically controlled ecosystems; and is directly correlated with stability, although this relationship is not wholly understood. Diversity also tends to be higher in older communities and low in newly established ones (Odum, 1971).

Odum (1971) indicated that error resulting from the failure to distinguish between closely similar species or counting life history stages as separate species is not critical in the calculation of species diversity indices, because different life history stages are, in themselves, part of diversity. Odum also stated that species are not the only useful units which can be used within the species diversity indices. Hurd and Wolf (1974) used species diversity indices of evenness and richness based on family level determinations to evaluate changes in predator trophic levels of an old field community in response to changes in prey populations. Wilhm (1968) developed an equation based on the Shannon-Weaver formula (Shannon and Weaver, 1949) to be used with biomass units instead of species numbers as he felt that the size of the organisms in an aquatic environment may

have at least as much bearing on the importance of the organism's contribution to the stability of the community.

Study Area

Location

The study area is located in Brevard County, on Merritt Island, a barrier island off the east coast of Florida (Fig. 1). The exact location is latitude 28°43'N and longitude 80°47'W. The study area is at the northwest end of the island, five miles from the Kennedy Space Center. The area is under the auspices of the U.S. Fish and Wildlife Service, Merritt Island National Wildlife Refuge.

History

Two mosquito control impoundments, established in the 1950's, but still dominated by salt marsh vegetation, were combined in 1973 by the elimination of retaining dikes. Additional dikes were breeched to allow entry of brackish water from the Indian River System (Fig. 1) to maintain habitat for the Dusky Seaside Sparrow (Ammospiza maritima nigrescens), a rare and endangered species. A system of canals still surrounds the study area.

Climate

The study area lies on the leeward coast of Merritt Island, close to the Indian River and experiences a sub-tropical climate. Listed in Table 2 are climatic data for the year beginning in February, 1974 and ending with January, 1975. The highest temperature recorded was in September (37.92°C) while the lowest temperature (9.04°C) was in February. Highest temperatures were recorded during June, July, August, and September. The longest average day came in June,

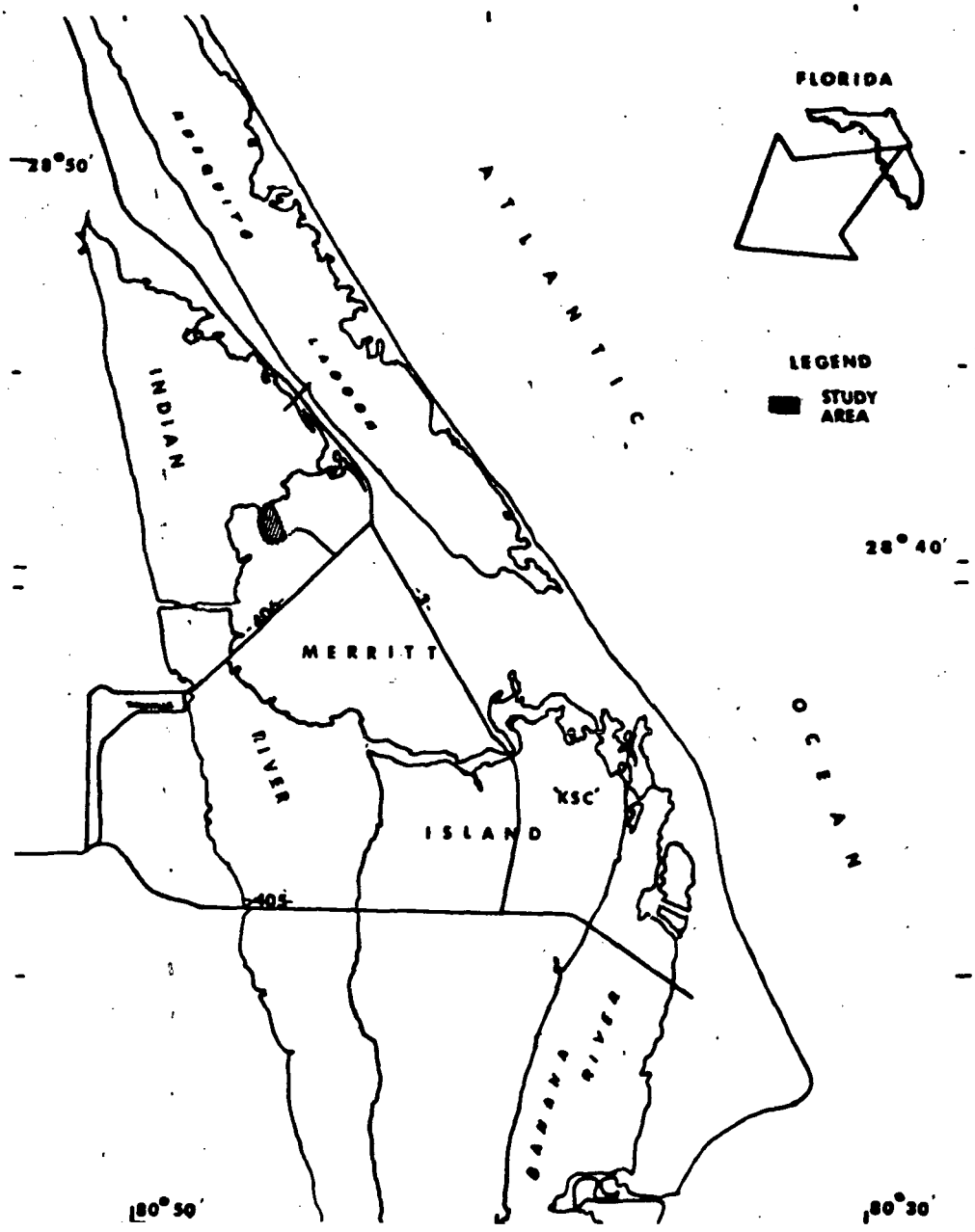


Fig. 1. Vicinity map of the study area indicating the main portion of Merritt Island, Florida, the Kennedy Space Center, Titusville, and the various access routes to the study site.

Table 2. Physical data obtained from the Kennedy Space Center on Merritt Island, Florida for the impounded salt marsh. Data includes climatic information for the period beginning in February, 1974 and ending with the last of January, 1975.

Month	Ave. Temperature (° C)			Ave. Rainfall (cm)	Ave. Daylength (hours)
	Max.	Min.	Ave.		
February	25.20	9.04	17.12	1.07	11.02
March	31.44	16.24	23.84	4.70	12.01
April	30.64	17.44	24.04	2.84	12.86
May	35.20	22.08	28.64	3.66	13.57
June	36.24	24.88	30.56	29.03	13.90
July	36.72	25.76	31.24	27.69	13.75
August	37.36	27.68	32.52	21.49	13.15
September	37.92	28.32	33.12	12.17	12.33
October	31.52	21.84	26.68	12.90	11.99
November	28.32	15.84	22.08	2.06	10.76
December	23.76	10.32	17.04	6.17	10.39
January	27.60	13.84	20.72	1.83	10.57

13.90 hours. Total rainfall for the year was 85.71 cm. Peak rainfall came in June (29.03 cm), July had the next highest amount (27.69 cm), and the lowest rainfall occurred in February and January, 1.07 and 1.83 cm, respectively.

Soils

Listed in Table 3 are the results of analysis of the pH, salinity and some macronutrients. Measured values of pH for the areas ranged from 6.6 to 6.3 in the SPD and DS areas. Salinity ranged from 4.7 to 3.3 in the SPD and DS areas. Where Juncus sp. were predominant pH values averaged 6.4 and salinity ranged from 2.8 to 3.1% between the 1974 and 1975 samples.

Vegetation

The impoundment is now a low water, high marsh of approximately 496 hectares and is essentially flat although it does contain many dips and swales. Dips or pannes accumulate water during the rainy season, but are usually transformed into shallow pools where salts accumulate as evaporation increases during the dry season. The marsh vegetation mosaic reflects the slight variations in elevation found within the impoundment

Provost (1967) described similar areas as grass salt marsh types representing a transition between high and low salt marsh. In the Atlantic salt marshes north of Florida, common high salt marsh vegetation consists primarily of Spartina patens and Distichilis spicata. Low salt marshes have S. alterniflora and Juncus roemerianus as dominants. The study area vegetation consist of both high and low marsh plants. Approximately 60% of the salt marsh

Table 3. Macronutrients and other pertinent edaphic parameters obtained from soil samples collected in April, 1974 and April and June, 1975 on a Merritt Island, Florida salt marsh.

Area	pH	Salinity (%)	Org. Matter (%)	P[a] (ppm)	K[a] (ppm)	Ca[a] (ppm)
SPD	6.6 (6.6[a])	4.7	11.0	5.3	206.0	660.0
DS	6.3 (6.6[a])	3.3	21.8	7.5	120.0	1730.0

[a]These values were obtained from samples sent to the U.S. Dept. of Agriculture Soil Testing Laboratory in Gainesville, Florida.

is dominated by Spartina bakerii (Merrill), Distichilis spicata (Loisel), and Sesuvium portulacastrum (Loisel). Because of the dominance of these species, two plant associations were selected for intensive study. Stands of concern were classified as the SPD and DS areas according to their dominant species. The SPD area is dominated by the Spartina and Distichilis species mentioned above. The DS area is dominated by the species of Distichilis and Sesuvium. Other conspicuous plants in the marsh include: Sabal, Juncus, and Laguncularia. A list of 20 species of the most conspicuous plants found in the marsh is presented in Table 4. Patterns of dispersion of dominant vegetation on the impounded area are illustrated in Fig. 2. Only 0.25 hectares were studied.

Of the three plants which were studied most intensely, sea purslane (Sesuvium portulacastrum) seemed to grow in greatest profusion. It was most common in the DS area, primarily near highly saline areas, and it was found in lesser quantities in the SPD area and in Juncus islands.

In the eastern portions of the study area away from the canal, more freshwater or upland vegetation was found (Fig. 2). Examples of this type of vegetation include: Typha sp., Senecio sp., and Sabal sp. These are referred to as members of the "Wet and Dry Prairie" vegetation by Long and Lakela (1972).

Approximately 32% of the marsh is covered by a halophytic combination of plants including: Distichilis sp., Paspalum sp., and Sesuvium sp. Another 21% of the marsh is covered by Juncus

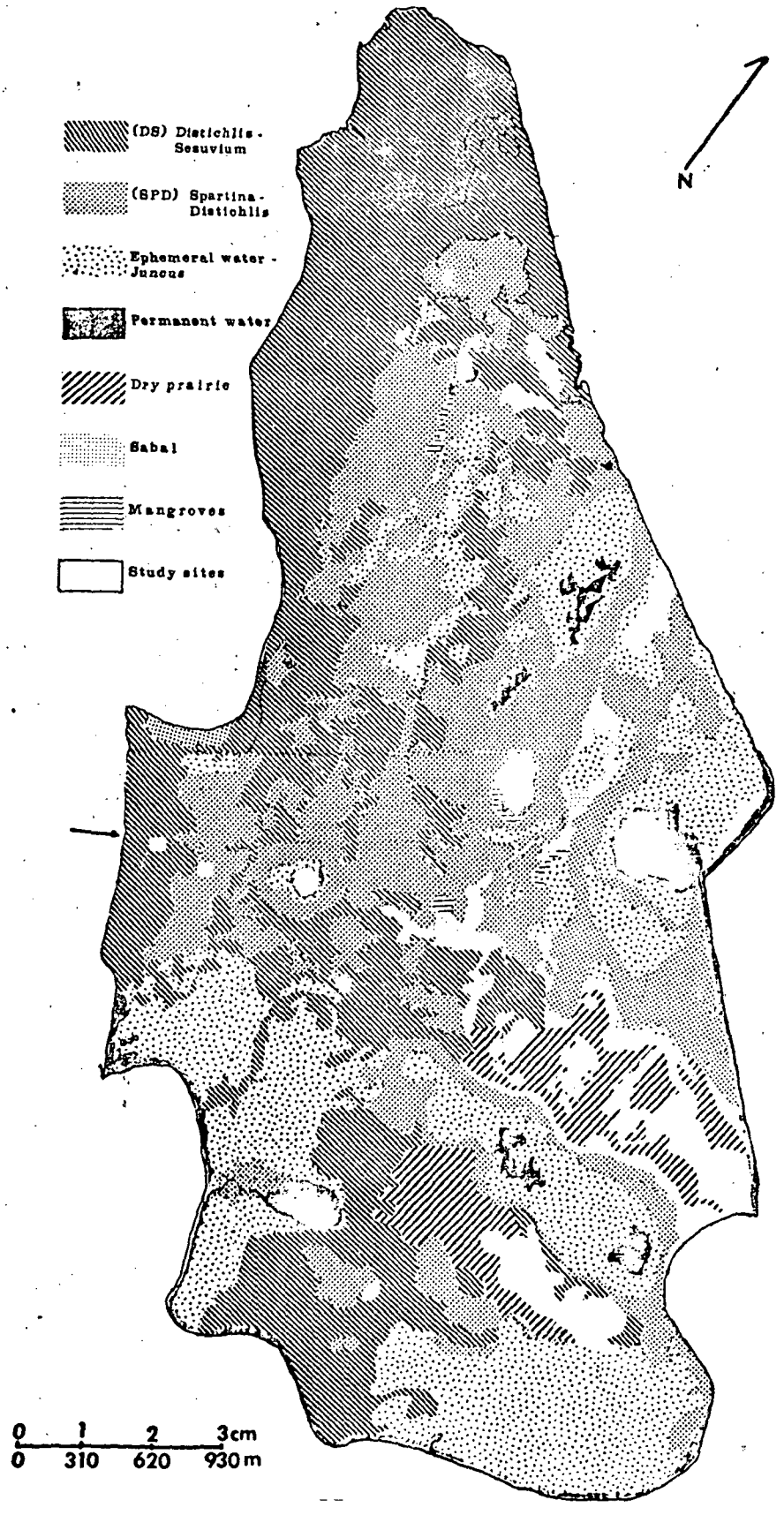


Fig. 2. Cover map of the Merritt Island, Florida salt marsh studied between February, 1974 and February, 1975. Major plant communities and other prominent topographical elements of the marsh are given. Scale 1 cm:310 m.

Table 4. Some of the more conspicuous plant species found on the study marsh on Merritt Island, Florida. These plants were chosen at random from throughout the marsh and do not represent the entire flora, only the more prominent species.

Taxonomic Family	Scientific Name[a]
Pteridaceae	Acrostichum aureum Loisel
Arecaceae	Sabal palmetto (Walt.)Lodd.
Poaceae	Andropogon glomeratus (L.) Distichilis spicata (L.) Paspalum vaginatum (Sw.) Setaria magna (Giseb.) Spartina bakerii Merrill Sporobolus virginicus Brown
Cyperaceae	Cyperus strigosus (L.)
Juncaceae	Juncus roemerianus (Scheele)
Asteraceae	Baccharis halimifolia L. Mikania scandens (L.)Willd. Pluchea purpurascens (Sw.) DC. Senecio glabellus Poir. Salidago sempervirens L.
Aizoaceae	Sesuvium portulacastrum (L.)L.
Amaranthaceae	Amaranthus cannabinus (L.)Sauer Philoxerus vermicularis (L.) R. Brown
Combretaceae	Laguncularia racemosa Gaertn.f.
Anacardiaceae	Schinus terebinthifolius Raddi

[a]Scientific names are from Long and Lakela (1972).

sp. and ephemeral water; 26% is covered by Spartina sp., Distichilis sp., and Sesuvium sp. The remaining 21% of the marsh is covered by open water and some of the "Wet and Dry Prairie" species and invading species such as the Baccharis sp.

Methods and Materials

Study Site Selection

Selection of the specific study sites was somewhat arbitrary. No "natural" salt marsh areas of substantial size exist on Merritt Island that are also afforded the protection of the Wildlife Refuge (personal communication, J. Baker). Therefore, much of the island was not useful for this research. A preliminary ground survey for potential study areas was completed in the fall of 1973. Criteria for study site selection were similar to those of Davis and Gray (1966): (1) its accessibility to transportation routes; (2) its protected status; (3) the types of plants available for study; (4) the homogeneity of the vegetation to be studied.

The study area is accessible to vehicle traffic by a graded road maintained by the Wildlife Refuge. The road is located adjacent to the marsh across the canal surrounding the area. A foot bridge was used for access to the study area from the road.

The marsh had a history of little disturbance when compared with other areas in the vicinity. Individual Baccharis halimifolia plants had been sprayed with defoliant chemicals approximately two years prior to the study. The adjacent impoundment east of the study area had been burned in 1973 to reduce the invasion of undesirable plants. The study area was also burned in the far eastern section at that time, but the research areas were not affected by this treatment. The entire area had been burned previously, but not within the two years prior to

the study. The edges of the marsh had been previously treated with pesticides for mosquito control just prior to the study, but penetration of the treatment was not far enough into the interior to affect the study areas. No hunting was permitted in the study area.

Diking of the natural salt marsh for mosquito control causes the marsh to change substantially (Provost, 1967; Miller and Egler, 1950). The salt marsh regime may be maintained as long as salt concentrations in the soil and water remain high and dilution with rainwater and runoff remain in equilibrium with evaporation. If rainfall is high or runoff (drainage) is greater than evaporation rates, and there is no way to return salts into the system, such as by tidal action, the salt marsh regime is changed first to a brackish and then to a freshwater system.

The marsh which was chosen for the research had large, nearly homogeneous stands of grasses and other herbs growing on it. This characteristic reduced the amount of variation among vegetation samples, and increased the ease with which samples could be gathered.

Vegetation Map

A relatively accurate vegetation map of the study area was constructed from aerial photographs taken in 1973 and furnished by NASA and personnel of the Merritt Island National Wildlife Refuge. The black and white and colored infrared photographs had been taken from an altitude of approximately 5000 feet.

Plant association boundaries were transferred onto tracing paper, then to mylars. Ground truth data were obtained by investigation

on foot.

Biological Parameters

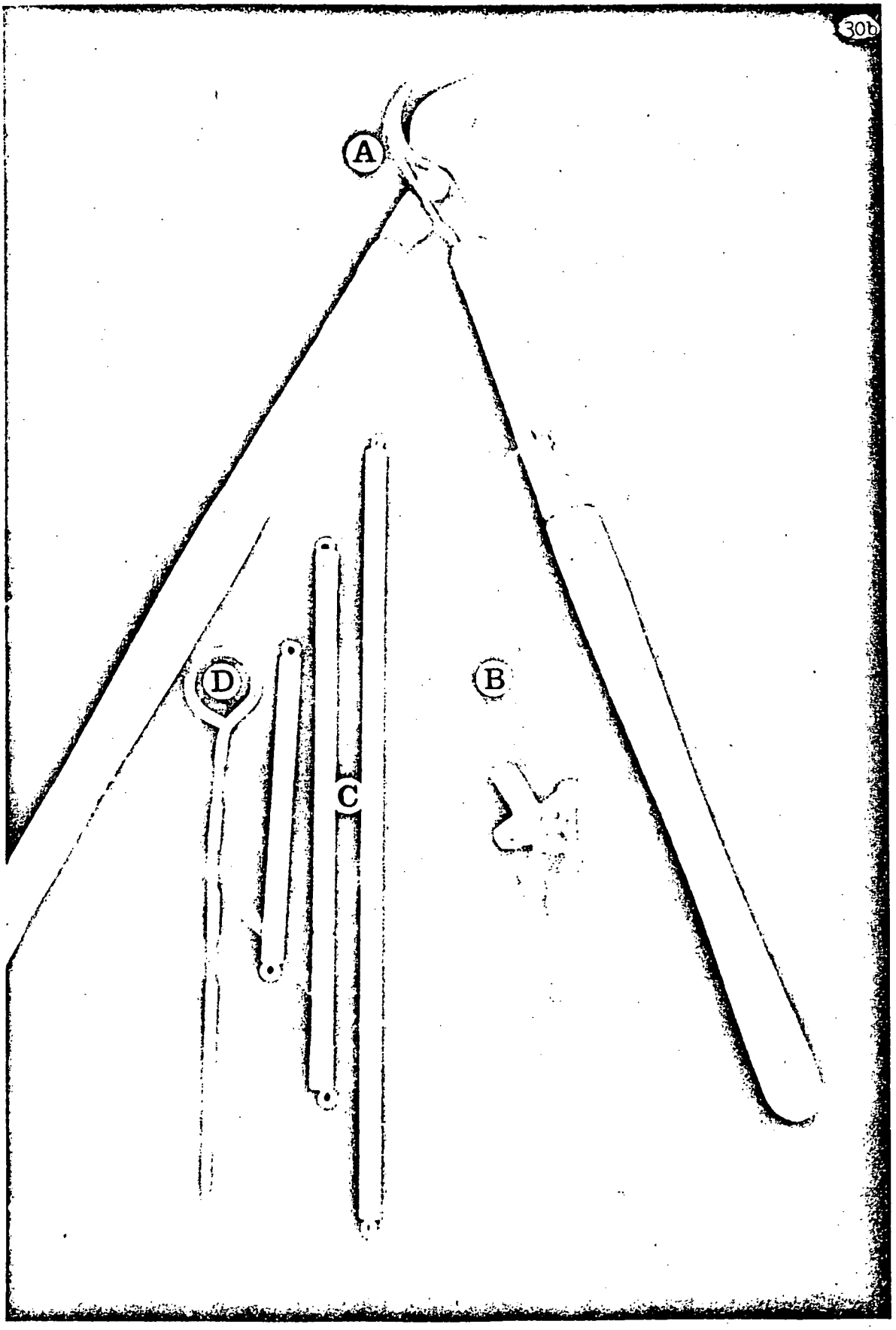
Standing Crop

Initial samples of standing crop were taken in appropriate stands from throughout the marsh. After three months it was obvious the variation between and within samples was unacceptable. Beginning in May, 1974 two specific areas were designated for collection of plant biomass. A 930 m^2 sample unit within each of the SPD and DS areas was surveyed and staked for ease of study. The units were divided into 10,000 subunits, each 0.092 m^2. Thereafter, these subunits within the study area were sampled at random. The investigator paced off the "X" and then the "Y" coordinates in the field, when locating sub-units for sampling.

Plant biomass was collected according to the short-term harvest procedure (Odum, 1971). Plants were harvested with grass and pruning shears (Fig. 3). In the SPD area all rooted vegetation within the quadrat was clipped to within 2 cm of the soil surface. Aerial portions of rooted vegetation hanging in or out of the quadrat were clipped. This was found necessary to obtain a representative sample, as the vegetation within this association is highly clumped with few plants between clumps.

In the DS association, plant material was uniformly distributed and abundant. Vegetation was sampled that was growing or hanging within the plot. Vegetation was clipped around the inside of the quadrat. Plant parts which belonged to rooted vegetation within the plot and which were hanging outside of the quadrat were not included

Fig. 3. Sampling equipment used to harvest vegetation samples on a Merritt Island, Florida salt marsh between February, 1974 and February, 1975. The letters have the following meaning: A-pruning shears; B-grass clips; C-various sized dowling used in quadrat construction; D-stakes used to hold the quadrats in place.


A
B
C
D

in the sample. The quantities of collected aerial parts from rooted plants outside the quadrat were assumed to be approximately equivalent to those of plants rooted within the plot which were excluded from the clipping. Plants were clipped to within 2 cm of the soil surface. By harvesting in this manner, only the standing living and dead aerial parts of the vegetation were sampled. Decaying plant debris was not collected.

Quadrats 0.1 m^2 were used to sample both of the study areas. In the SPD area the quadrat dimensions were 5 X 2 dm, whereas the DS area quadrats were 3.3 X 3.3dm. The rectangular plot was used in the clumped area (SPD) because it was more effective in reducing variation between samples than the square plot. This is probably a result of the rectangular quadrat simultaneously crossing areas of high and low plant densities (Kershaw, 1964). Quadrat frames were constructed from 1.2cm diameter dowling rods connected at their corners to form the appropriate area.

Clipped vegetation was placed in labeled plastic bags, removed to the laboratory, and immediately frozen. Samples remained frozen until processing. After thawing, samples were spread onto newspapers and the plants were separated into piles according to species and living or dead components. Succulents were the first species to be removed from the rest of the sample, since they were most susceptable to fungal infestations and desiccation. Grasses were separated next. After species segregation, living and dead portions of each plant were determined and removed to separate piles. Living plant material was identified on the basis of the chlorophyll content. Green or

yellow-green parts of plants were considered to be living, while brown or black parts were considered to be dead. No distinction was made between standing dead and dead material removed from living plants. For each species, each month, there was a standing living and a standing dead component.

Living plant components were cut into small sections and a wet weight was obtained. This green material was dried in a force-draft oven (Blue M, model OV-560A-2) for 48 hours at 100° C or until a constant dry weight was obtained. Dried, weighed living material was placed in plastic bags and stored until needed for caloric determinations. Dry weight, only, was determined for dead material after air drying for at least 10 days.

Calorimetry

All dried living plant material was consolidated according to month, species, and sample area. Samples were homogenized several times. The first homogenation on the combined samples was carried out by hand-stirring for one min. This sample was subsampled in a random manner, and homogenized in a Waring blender for approximately one min., or until the sample was ground into a coarse powder. These samples were placed in plastic bags and frozen until needed. Frozen samples were subsampled as appropriate, and the coarsely ground material was reduced to a very fine powder with a Wig-L-Bug amalgamator (Cresent model 5A). This finely ground powder was used to make pellets for calorific determinations. The fine powder was stored in a vacuum desiccator over $CaCl_2$ and at a vacuum of 18 atms.

The powdered vegetable matter was combined with a binder, benzoic

acid, and pelletized. Total weight of the pellets was maintained at between 8 and 20 mg. The percentage of benzoic acid in the pellet was maintained at not more than 50%.

Procedures for the ignition, and apparatus used in the ignition of the pellets were discussed by Paine (1971), Phillipson (1964), and the calorimeter operational manuals. Pellets were place on a small platinum dish 1 cm in diameter, and inserted into a Phillipson microbomb calorimeter (Gentry) for calorific determinations. The microbomb and associated apparatus is shown in Fig. 4. The non-adiabatic calorimeter used (Phillipson, 1964) consisted of a microbomb, sensing unit (including a power supply and thermocouples combined in a stand) and a recording unit comprised of a potentiometer and pen recorder (Honeywell Electronik Model 194).

Sample pellets were secured in the bomb with a platinum ignition wire (4 cm long and with a diameter of 0.015 cm), and 0.1 ml of distilled water was placed in the bomb's well (Fig. 4). The bomb was sealed airtight and 30 kg/cm^2 of oxygen (welder's grade) was injected into the sealed bomb. The bomb was cooled by dipping in a vat of cool water and placed on the sensing stand. The bomb's power supply was connected by appropriate leads and the insulating steel beaker and styrofoam shell were placed in position over the bomb. The beaker and shell were to keep air currents from causing temperature fluctuations within the bomb. The recorder was turned on and the temperature of the bomb and the environment within the steel beaker were allowed to equilibrate. The equilibration process required about 10 min. The equilibrium period was plotted as a line

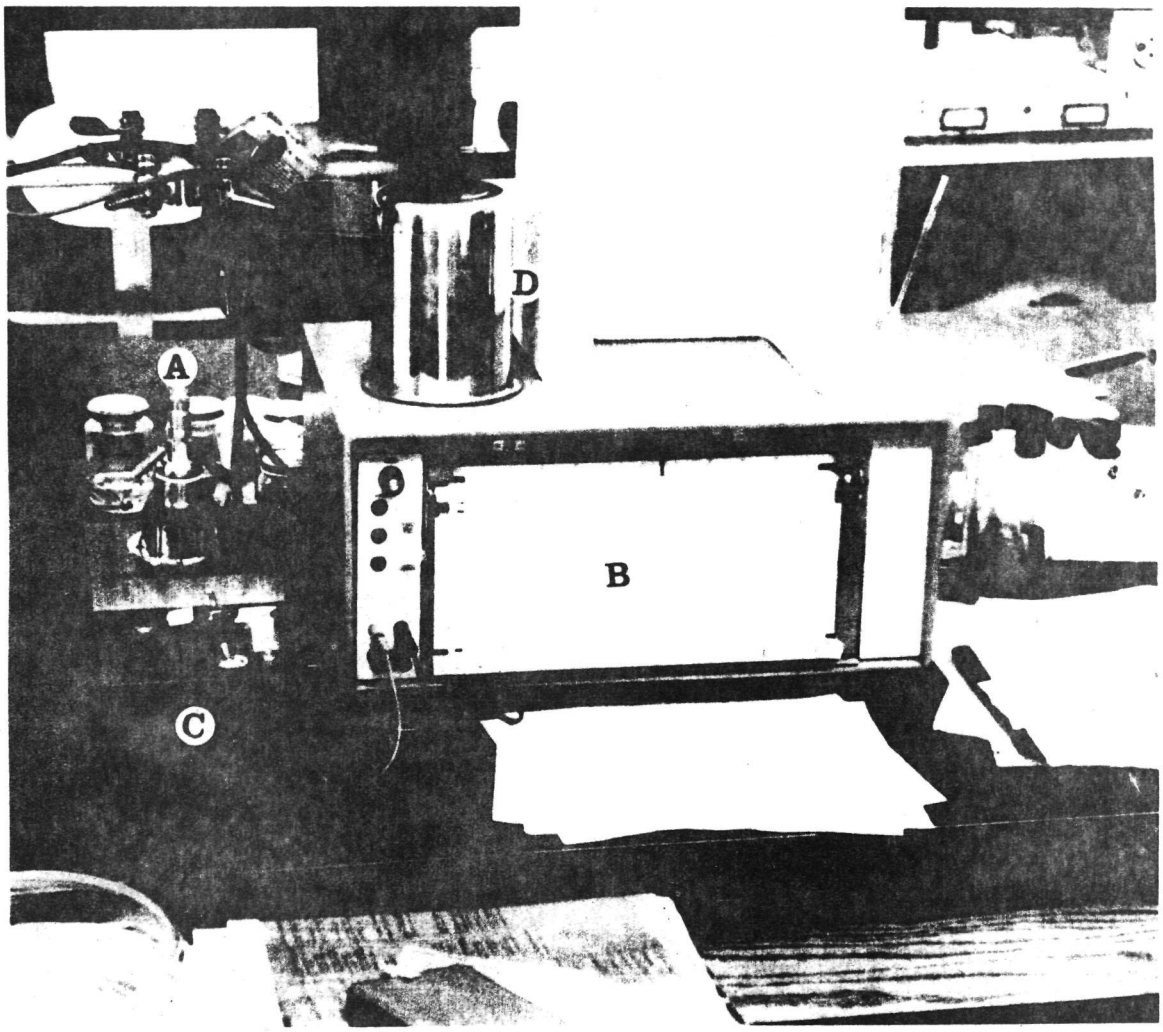


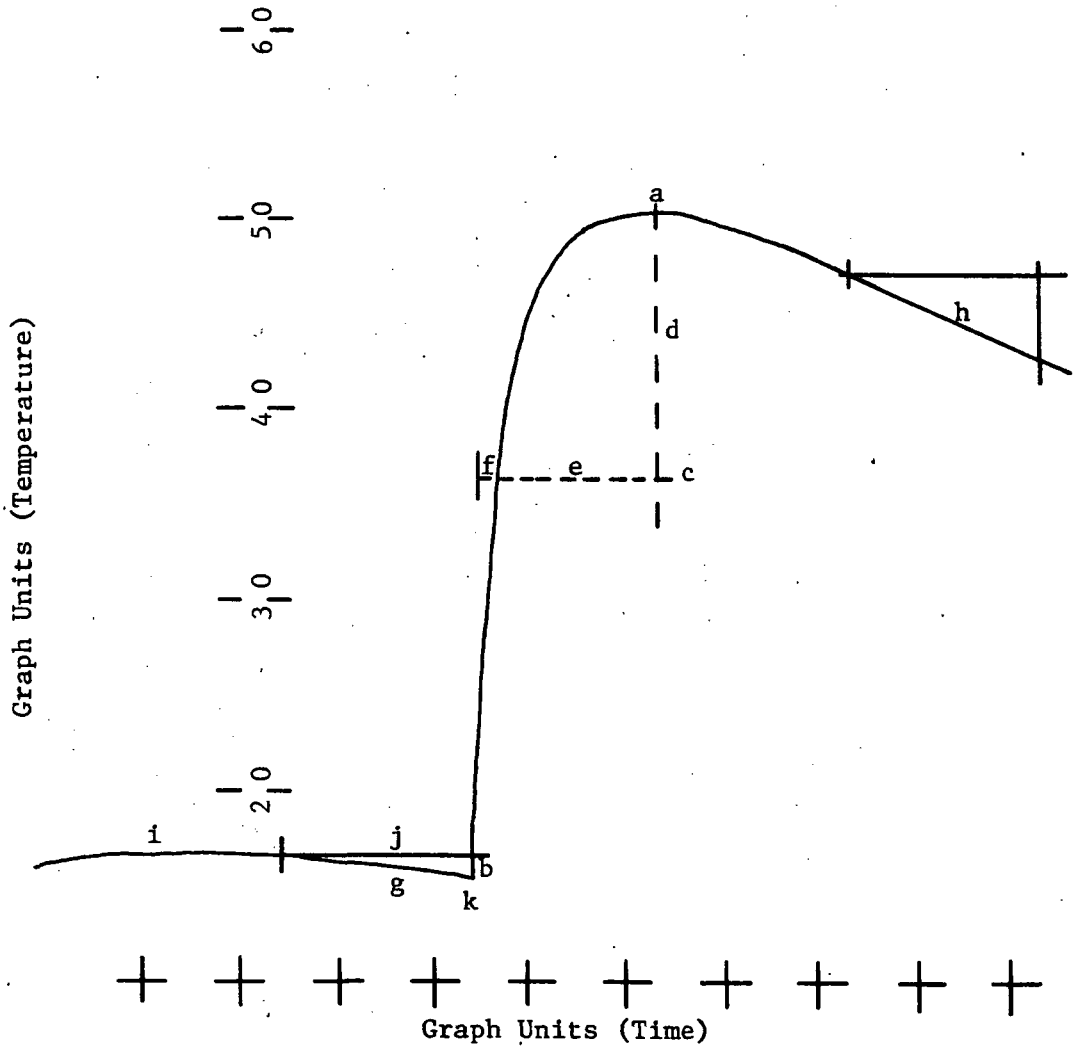
Fig. 4. The Phillipson Microbomb Calorimeter used in calorific determinations of plant material collected from a Merritt Island, Florida salt marsh between February, 1974 and February, 1975. The letters have the following meaning:

moving in a positive (left) direction from the beginning point (Fig. 5). At equilibrium a straight line in a vertical direction was produced. After equilibrium, the line is slowly skewed towards the right (a negative direction). This indicated that the temperature of the bomb was equilibrating with that of the room. The investigator allowed ten vertical units to pass equilibrium to establish a constant rate of descent. The pellet was ignited by applying 32 volts D.C. into the bomb chamber.

As the sample ignited, the temperature of the bomb increased. This rise in temperature produced a potential in the thermocouples of the sensing unit and was recorded as a slowly forming hyperbolic curve to the left. The peak temperature was recorded approximately 10 min. after firing in a sample of the size used. After the peak was reached the graph declined towards zero. At least two consecutive horizontal units (equal to 10 vertical units) were recorded past the peak to establish a constant rate of decline. The recorder was turned off and the process was repeated. Four replicates were used to calculate final caloric values.

For each of the plant speces under scrutiny, an ash-free dry weight (AFDW) correction was determined for the caloric values. Three crucibles and tops were brought to a constant weight in a Thermolyne Muffle Furnace (Model F-A1730) at a temperature of 500°C. Consolidated samples from each of the types of plants of interest were weighed and placed in the preweighed crucibles. Plant material was taken from the finely ground matter used in the pellets. The percent ash was calculated and applied to the caloric values obtained

Fig. 5. Example of graph obtained during calorific determinations of plant materials collected from a salt marsh on Merritt Island, Florida between February, 1974 and February, 1975. The letters have the following meanings: a-Peak; b-Base; c-60% Rise; d-line from Peak to 60% Rise; e-horizontal distance from Peak line left to graph line; f-horizontal distance from Peak line left to next graph paper unit; g-Pre-Fire Slope; h-Post-Fire Slope; i-Temperature equilibrium; j-10 units before Ignition; k-Ignition.



from the ignition of the vegetable matter to give a value in cal/ash-free dry weight (AFDW). Other corrections were applied to the caloric values, but these will be discussed under calculations.

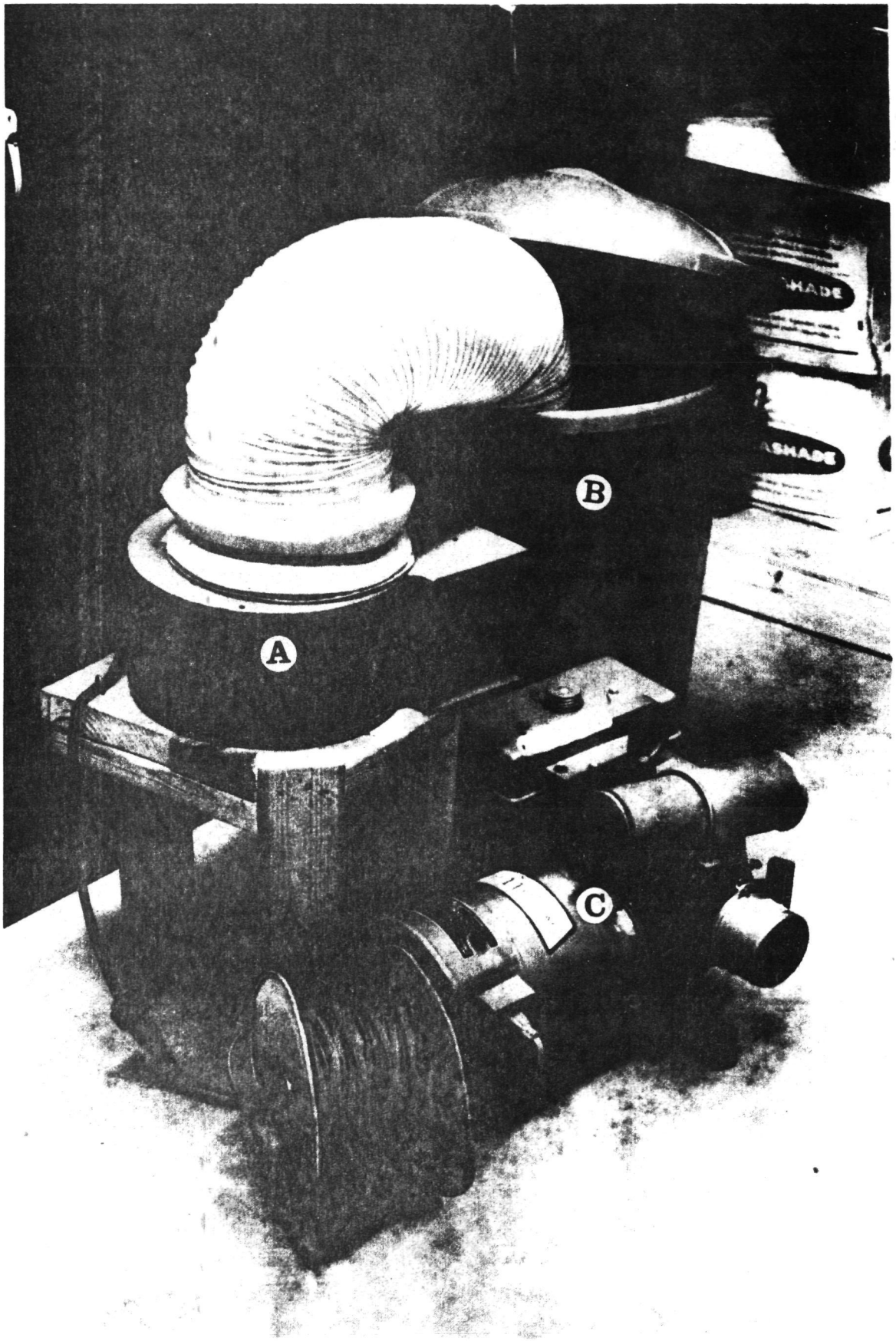
Macroinvertebrates

Macroinvertebrates, largely insects and arachnids, from the foliage, litter, and soil were sampled. Representatives of three trophic levels were captured. Sample sites were adjacent to those used for collection of plant biomass. Plant communities sampled were comparable, thus results can be correlated with measures of plant productivity.

Aerial macroinvertebrates were sampled biweekly from August, 1974 to February, 1975 (6-months). Samples were taken objectively in the late morning by methods adapted from Dietrich (1959), Harrel and Davis (1965), Barrett (1968), and Hurst (1970). Equipment used in the collection of above-ground invertebrates appears in Fig. 6. A plastic cylinder, the open end of which was 0.132 m^2, was set at random over a site to be sampled. A removable top covered the cylinder during its placement over the foliage. When the cylinder was in position, the suction sampler was inserted through the cylinder top and invertebrates were sucked into a standard insect collection net fastened to the sampler hose. Collection time was approximately 30 s.

The suction sampler consisted of a squirrel cage induction fan mounted on a base, 3 m of household dryer conduit, and an insect collection net. The induction fan was run by a 1/4 horsepower electric

Fig. 6. Vacuum sampler used in the collection of above-ground macro-invertebrates on a Merritt Island, Florida salt marsh between August, 1974 and February, 1975. The letters have the following meaning: A-sampling unit with induction fan, conduit and collection net; B-collection container with lid; C-power supply.


A
B
C

motor and powered by a 1100 watt, 3 horsepower, Sears power plant (Model 143.611042).

After collection, debris containing invertebrates was transferred to labeled plastic bags and maintained at freezing temperatures. After 10 days invertebrates were hand picked from the sifted debris and placed in labeled sample jars containing FAA (Formalin-Alcohol-Acetic Acid) as a preservative. Organisms as small as 0.2 mm were picked from the debris.

Soil invertebrates were collected once a month from August, 1974 to February, 1975 (6 months). Procedures modified from those of Cox (1972) and Teal (1962) were used to sample at random from the SPD and DS areas. An auger constructed from a 20-cm length of plastic water conduit (diameter of 10.2 cm) was pushed into the soil four cm and withdrawn containing appropriate quantities of soil. The upper two cm of soil was separated from the remaining sample with a putty knife and placed in a labeled plastic bag. There were five samples taken from each community, each month. After collection, the soil was transported to the most convenient source of brackish water and washed with a #40 limnological seive-bucket with openings of 0.42 mm. This removed superfluous sand and organic debris. Remaining material was returned to its respective container and taken to the laboratory where a Tullgren funnel apparatus (MacFayden, 1961) was used to extract invertebrates (Fig. 7). Organisms were preserved in FAA and stored until their identification. All invertebrates were identified to at least the family level based on standard references (Borror and DeLong, 1964; Borror and White, 1970; Jaques, 1947, 1951; Helfer, 1963;

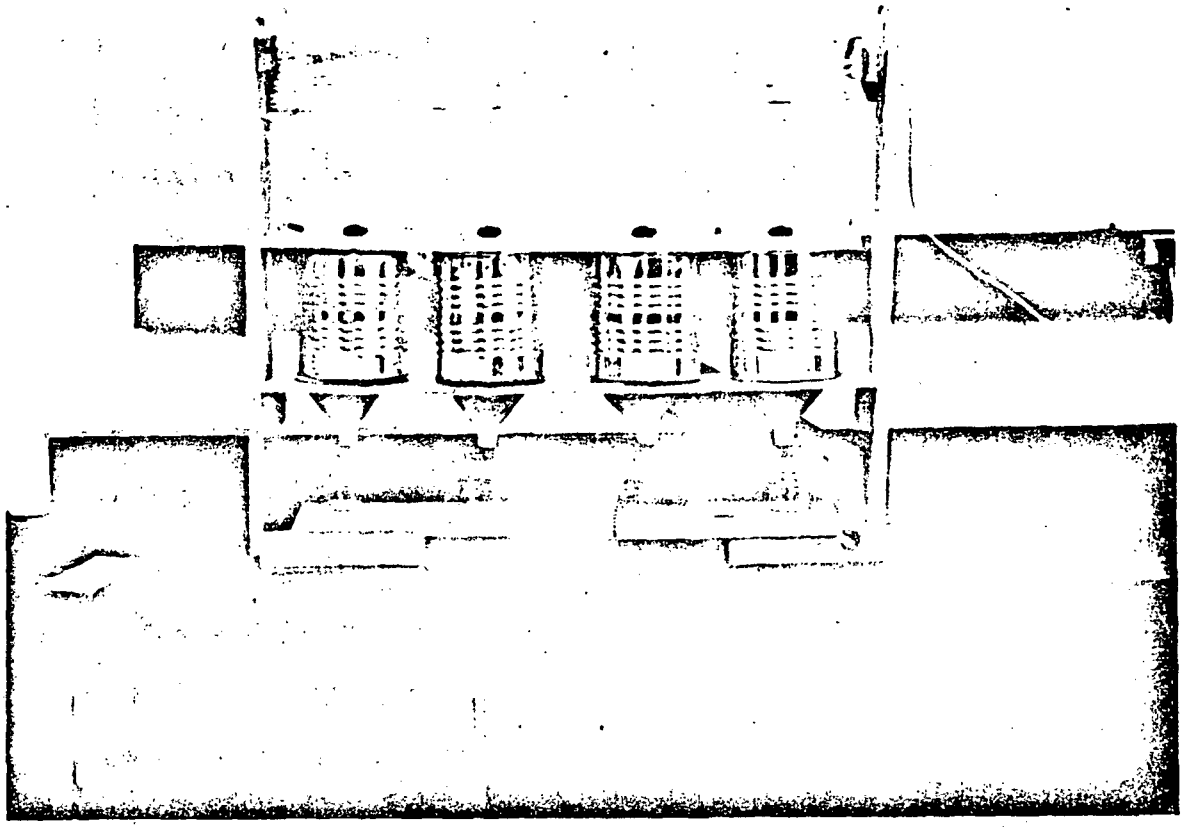


Fig. 7. Tullgren soil and litter macroinvertebrate extractor used to obtain samples of these organisms from the soil of a Merritt Island, Florida salt marsh. Collections were made between August, 1974 and February, 1975.

Kaston, 1953; and Chu, 1949). Enumerations were made by feeding type. A Baush and Lomb binocular dissection scope and a Swift compound bright field microscope were used in the identifications.

Physical Parameters

Climatological information including maximum, minimum and average temperature and average rainfall was obtained from the meteorological unit at NASA's Kennedy Space Center (KSC). Solar information was calculated from values obtained from the 1974-1975 Almanac. Data were collected for the 12 month period beginning in February, 1974 and ending in January, 1975. Weather and solar cycles were used to evaluate the correlation between peak growth periods of vegetation and densities of macroinvertebrates.

Soil data on pH and salinity was obtained by analyzing core samples taken in April, 1974 and April, 1975. Duplicate soil cores were taken with a standard soil auger (Oakfield model, 2 X 15 cm) in each of the SPD and DS areas. Methods for the determination of pH and salinity followed Rubins and Welcher (1963). First, a slurry was produced from the soil using a 1:1 ratio of soil and distilled water for pH. An Orion Research pH-meter (Digital Model 701) was used. Salinity was determined by adding an additional 30 ml of distilled water to the above slurry and reading the value directly from a YSI salinity-conductivity meter (Model S-C-T).

Similar soil samples were collected in June, 1975 and sent to the U.S. Department of Agriculture Soil Testing Laboratory, Gainesville, Florida for analysis of macronutrients.

Data Analysis

Net Primary Production

Net primary production was calculated from equations discussed by Milner and Hughes (1968), Odum (1971), and Waits (1967). The equations are as follows:

$$(1)\quad P\ (g/m^2) = \sum_{i=1}^{n} (Bi_t - Bi_{t-1})$$

Where: Total annual net primary aerial production (P) is equal to the sum of (Σ) the differences between the biomass of the ith sampling (Bi_t) and the biomass of the previous sampling period (Bi_{t-1}).

$$(2)\quad P\ (g/m^2) = \sum_{i=1}^{n} (Bi_t - Bi_{t-1}) + D$$

Where: Total annual net primary aerial production (P) is equal to the sum of (Σ) the change of weight of the live shoot material from the ith sampling (Bi_t) and the biomass of the previous sampling period (Bi_{t-1}) plus the sum of the change in weight of dead material (D) between time t and t-1.

Net primary production values were calculated on a biomass and caloric basis for the entire year.

In equation (1) previously accumulated living material (dead) is not considered. This will underestimate the production value of the system. The second equation takes the dead material into consideration, but should be used with paired plots (Wiegert and Evans, 1964). Neither of the equations takes into account that portion of the vegetation which is consumed by herbivores or plant material lost due to respiration. Owing to the lack of information on herbivore consumption and plant respiration rates for these species, no corrections

for these losses were considered.

Average standing crop values for each of the dominant species of the SPD and DS areas were obtained for living and dead aerial material. Standing living and dead biomass were considered.

Calorimetry

Caloric values for dominant SPD and DS species were calculated from equations obtained from the calorimeter operational manual. Data for calculating the calorific values for a substance is taken directly from the graph of the results of the combustion of the material. The following pertinent values were determined (Fig. 5):

(1) The pre-fire change in slope per unit time
(2) The post-fire change in slope per unit time
(3) The observed rise from firing to the peak
(4) Time necessary for 60% of the rise
(5) Time necessary for the final 40% of the rise

Time was measured in chart paper units (1 vertical unit equaled 10 horizontal units).

Theoretical considerations show that the pre-fire change in slope should be considered to apply during the first 60% of the rise and the post-fire change is operative during the time from 60% of the rise to the peak. The post-fire change in slope determines the largest part of the total correction used to calculate the total corrected rise. The change of slope was always in a left to right direction and negative. Because the change of slope was negative, the change corrections were multiplied by the time and added to the observed rise.

The following procedure was used to calculate the calorific values of the 53 different vegetation samples (Fig. 5).

(1) Find the Base = the number of units from which the ignition of the material took place.
(2) Find the Peak = the number of units at which the maximum temperature is reached after the ignition of the material.
(3) Find the Rise = Peak - Base
(4) Find the Total Corrected Rise = (Rise - Wire Correction) + Time Correction.
(5) Find the Caloric Value of the sample = (Total Corrected Rise) (Benzoic Acid Calibration Factor) / (Pellet Weight of Sample - Unburned Residue) .
(6) Find the Caloric Value of the Sample in Ash-Free Dry Weight Units = (Total Corrected Rise) (Benzoic Acid Calibration Factor) / (Pellet Weight of The Sample) - (Unburned Residue + Ash of The Residue) .

The procedure for obtaining the Time Correction, Wire Correction, and the Benzoic Acid Calibration Factor is as follows:

(1) Find the Time Correction = Pre-fire Slope Correction + Post-Fire Slope Correction.
(2) Find the Wire Correction = in this investigation it was found to be 0.5 units. This is equal to the weight of platinum wire times heat of combustion of platinum.
(3) Find the Benzoic Acid Calibration Factor = (Heat of Combustion of Benzoic Acid = 6.318 gcal/mg) (Weight of Benzoic Acid in a Pellet) / (number of chart units in the Total Corrected Rise obtained when burning a predetermined quantity of benzoic acid in the calorimeter).

The procedure for obtaining the pre- and post-fire slope corrections is as follows:

(1) In reference to Fig. 5, multiply the Rise by 0.6 to obtain 60% mark of the Rise.
(2) Add the value from (1) to the Base.
(3) Draw a vertical line from the Peak to the Base.
(4) Counting from the right, determine the number of paper units from the vertical line to the graph at the 60% mark = Post-fire Factor.
(5) Counting from the right, estimate the percentage of a graph unit from the graph at the 60% mark to the next graph unit to the left of the graph = Pre-fire Factor.
(6) Determine the slope of the graph line before and after the ignition of the sample.
(7) Multiply the Pre-fire Slope by (5) = Pre-fire

Correction of the Slope.

(8) Multiply the Post-fire slope by (4) = Post-fire Correction of the Slope.

A portion of the caloric content of the pellet was due to benzoic acid and had to be subtracted from the total caloric content.

The benzoic calibration factor was recalculated every 30 determinations by igniting three samples of benzoic acid. Values did not vary more than 0.01 gcal for the duration of the research. All caloric values were expressed as either cal/g of sample or cal/gAFDW of sample. Calculations for the caloric values were performed on a Monroe programmable calculator (Model 1860).

Regression Analysis

Linear regressions were calculated for the following combinations of variables: (1) dead versus living standing crop biomass (SCB); (2) net primary production for each species versus changes in physical parameters; (3) caloric values versus changes in physical parameters; (4) overall species diversity and dominance of macroinvertebrates versus changes in each of the physical parameters and SCB, and; (5) individual trophic group diversity of the macroinvertebrates versus appropriate resource bases (e.g., predators versus saprovore and herbivore dominance and diversity).

T-Test

Student's T-Test was used to compare the means of the following:

(1) The net primary production of the plants of the SPD and DS areas, and

(2) Total caloric values from each of the SPD and DS areas.

Species Diversity

The species diversity of the macroinvertebrates for the SPD and DS areas was determined using the classifications of the organisms to the family level. The Shannon-Weaver (Shannon and Weaver, 1949) and the Simpson (Simpson, 1949) diversity indices were used for this purpose. Redundancy (Wilhm and Dorris, 1966) was also calculated. The FTU IBM-360-75 computer was used for the batch processing of the statistical and diversity calculations. Programs for the calculation of statistical analysis and diversity indices were developed from formula in Steele and Torrie (1960); Lloyd, Zar, and Karr (1968); Wilhm and Dorris (1966); and Simpson (1949).

The Shannon-Weaver index is sensitive to changes in both the numbers of organisms with respect to each species as well as the overall number of organisms in the sample. Simpson's index is more sensitive to changes in numbers of organisms with respect to each species, therefore is a measure of dominance (Poole, 1974). For the Simpson index (Si), possible values range between zero and one, whereas the Shannon-Weaver index (H') may have theoretical values from zero to infinity. Redundancy (R) is also a measure of dominance of a species. If the majority of individuals in a sample are represented by one species, the species dominates the community and redundancy (R) and Simpson's (Si) measures approach one in value. Equitability (E) is a measure of the evenness of distribution of organisms among all the species and may range from zero to one. For example, if all the organisms in a sample belong to only one species,

equitability is low (E=0), diversity is low (H'=0), and redundancy (R=1) and dominance (Si=1) are high.

Results and Discussion

Net Primary Production

Net primary production values for the dominant species by month and per year are found in Table 5. Values marked "1" were calculated with only monthly differences in live standing crop biomass. Values which are marked "2" were calculated by summing the values from "1" and those of the differences in dead standing crop biomass for each month. These values do not take into account the disappearance or decomposition rates of the sampled plants, thus may underestimate the actual value of NPP by approximately 15% (Wallentinus, 1973). The actual value of NPP of the species surveyed probably lies somewhere between the values of "1" and "2".

Often monthly NPP values were negative (Table 5). The greatest number of negative values appeared in the calculation of NPP for the SPD area. An increase in sample size may have modified this result.

Within the SPD stand, the greatest yearly NPP was attained by Spartina bakerii with values of 707.85 and 1,521.29 $g \cdot m^{-2} \cdot yr^{-1}$ (3087.71 and 6636.01 $kcal \cdot m^{-2} \cdot yr^{-1}$) (Table 5). Distichilis spicata in the DS stand had a NPP of between 371.88 and 1,506.07 $g \cdot m^{-2} \cdot yr^{-1}$ (1,670.99 and 6,767.32 $kcal \cdot m^{-2} \cdot yr^{-1}$). Values for methods "1" and "2" were significantly different ($p < 0.05$). Net primary production for Sesuvium portulacastrum ranged between 191.36 and 238.09 $g \cdot m^{-2} \cdot yr^{-1}$ (1,232.24 and 1,533.16 $kcal \cdot m^{-2} \cdot yr^{-1}$) and 451.93 and 569.65 $g \cdot m^{-2} \cdot yr^{-1}$ (2,270.16 and 2,861.50 $kcal \cdot m^{-2} \cdot yr^{-1}$) for the SPD and DS areas

Table 5. Comparisons of monthly net primary production of above-ground biomass for each of the plant species studied on Merritt Island, Florida between February, 1974 and February, 1975.

Time Interval	Net Primary Production ($g \cdot m^{-2} \cdot mo^{-1}$)				
	SPD			DS	
	Spartina	Distichilis	Sesuvium	Distichilis	Sesuvium
Feb-Mar					
1[a]	-631.77	-4.01	86.45	-9.01	-55.76
2[b]	-1040.14	-11.79	113.19	12.58	99.88
Mar-Apr					
1	58.00	50.22	-105.19	207.41	-35.09
2	-1.18	69.49	-130.24	329.46	-162.99
Apr-May					
1	92.68	-20.33	91.22	10.13	-37.84
2	182.41	-11.66	107.96	396.94	-56.59
May-Jun					
1	32.96	-30.38	-64.06	-88.27	31.80
2	153.02	-68.03	-70.19	443.61	48.36
Jun-Jul					
1	165.07	111.55	-28.58	-45.75	27.27
2	456.39	218.65	-40.88	92.11	30.88
Jul-Aug					
1	-71.72	34.04	0.10	-105.10	264.08
2	16.86	199.51	0.10	-94.57	263.39
Aug-Sep					
1	289.80	38.96	0.05	141.09	-263.55
2	359.68	-13.56	2.51	231.37	-259.13
Sep-Oct					
1	-2.65	-72.80	-0.15	-83.98	128.76
2	226.75	242.73	-2.61	-146.83	127.14
Oct-Nov					
1	-179.02	-5.77	1.08	13.25	-92.39
2	-49.10	-248.16	1.08	-37.31	-73.64
Nov-Dec					
1	-68.46	-11.31	12.46	-18.50	-15.95
2	-345.95	-60.32	13.25	-33.39	-8.80

Table 5. Continued.

Time Interval	Net Primary Production ($g \cdot m^{-2} \cdot mo^{-1}$) SPD Spartina	SPD Distichilis	SPD Sesuvium	DS Distichilis	DS Sesuvium
Dec-Jan					
1	54.66	-60.16	-13.34	-8.61	-32.44
2	126.18	-193.43	-14.13	-162.14	-44.27
Total 1	707.85	234.77	191.36	371.88	451.93
2	1521.29	730.38	238.09	1506.07	569.65

[a]Calculated with only the living standing crop biomass.
[b]Calculated with the living and dead standing crop biomass.

respectively. These values were not shown to be significantly different ($p < 0.05$).

My estimates of NPP were considerably greater than grassland values of Van Hook (1971) who obtained 716.19 and 292.10 $kcal \cdot m^{-2} \cdot yr^{-1}$ for Festuca and Andropogon sp. respectively. He also obtained a value of 140.40 $kcal \cdot m^{-2} \cdot yr^{-1}$ for an unnamed forb. The values obtained in my study do compare favorably with results of other authors (Table 6). Nixon and Oviatt (1973), from Rhode Island, reported values for tall (2.8) and short (1.1) Spartina alterniflora, and S. Patens (1.3 $kcal \cdot m^{-2} \cdot yr^{-1}$). Menhinick (1967) found a Sericea lespedeza stand to have a NPP of 2550 $kcal \cdot m^{-2} \cdot yr^{-1}$.

Highest monthly primary production values for S. bakerii were attained during the periods of June-July and August-September, 1974 (Table 5). The peak production intervals for Distichilis and Sesuvium on the SPD area were June-July, September-October, and February-March, April-May. In contrast in the DS community Distichilis production peaked in the intervals of March-April and May-June. Sesuvium peaked during the monthly intervals of July-August and September-October.

In the SPD stand, Distichilis and Spartina manifested peak production intervals which overlapped during June-July (Table 5). This occurrence suggests competition between the two for critical resources is not important at this time in the growing season.

Apparently peak monthly NPP for the major plant species occurred during periods of most favorable environmental conditions. The production peak in the latter part of the summer was associated with abundant water, hours of sunlight and more stable temperatures

Table 6. Net primary production per annum of different species of *Spartina* and *Distichilis spicata* as recorded by other workers and the present study.

Author(s)	Date	Net Primary Production ($g \cdot m^{-2} \cdot yr^{-1}$) *Spartina* sp.	*Distichilis spicata*
Harper	1918	993[a]	-
Smalley	1961	985[b]	-
Morgan	1961	445[b]	-
Odum	1961	2000[b]	-
Good	1965	300[c]	-
Williams &	1966	650[b]	-
Murdoch		450[b]	-
		290[b]	-
Waits	1967	1300[a]	670
Foster	1968	560[d]	-
Stroud &	1969	1563[b]	-
Cooper		280[d]	-
Wass &	1969	1560[b]	360
Wright		1410[b]	-
		695[d]	-
Keefe &	1973	427-	-
Boynton		558[c]	-
Nixon &	1973	840[b]	-
Oviatt		432[d]	-
		430[a]	-
Odum & Fanning	1973	2883[e]	-
Gabriel & de la Cruz	1974	475[c]	63
Present Study	1974	708-1521[f]	372-1506

[a]*Spartina patens*; [b]*S. alterniflora*; [c]unspecified *S. alterniflora*; [d]short *S. alterniflora*; [e]*S. cynosuroides*; [f]*S. bakerii*.

(Table 2). Another period of high productivity occurred near the end of the dry season (winter) when rain and sunlight were becoming more abundant and increasing temperatures stimulated the nearly dormant vegetation. Spartina bakerii, which blooms during January and February in this area, must have utilized energy reserves from the root system at this time to increase production as it did.

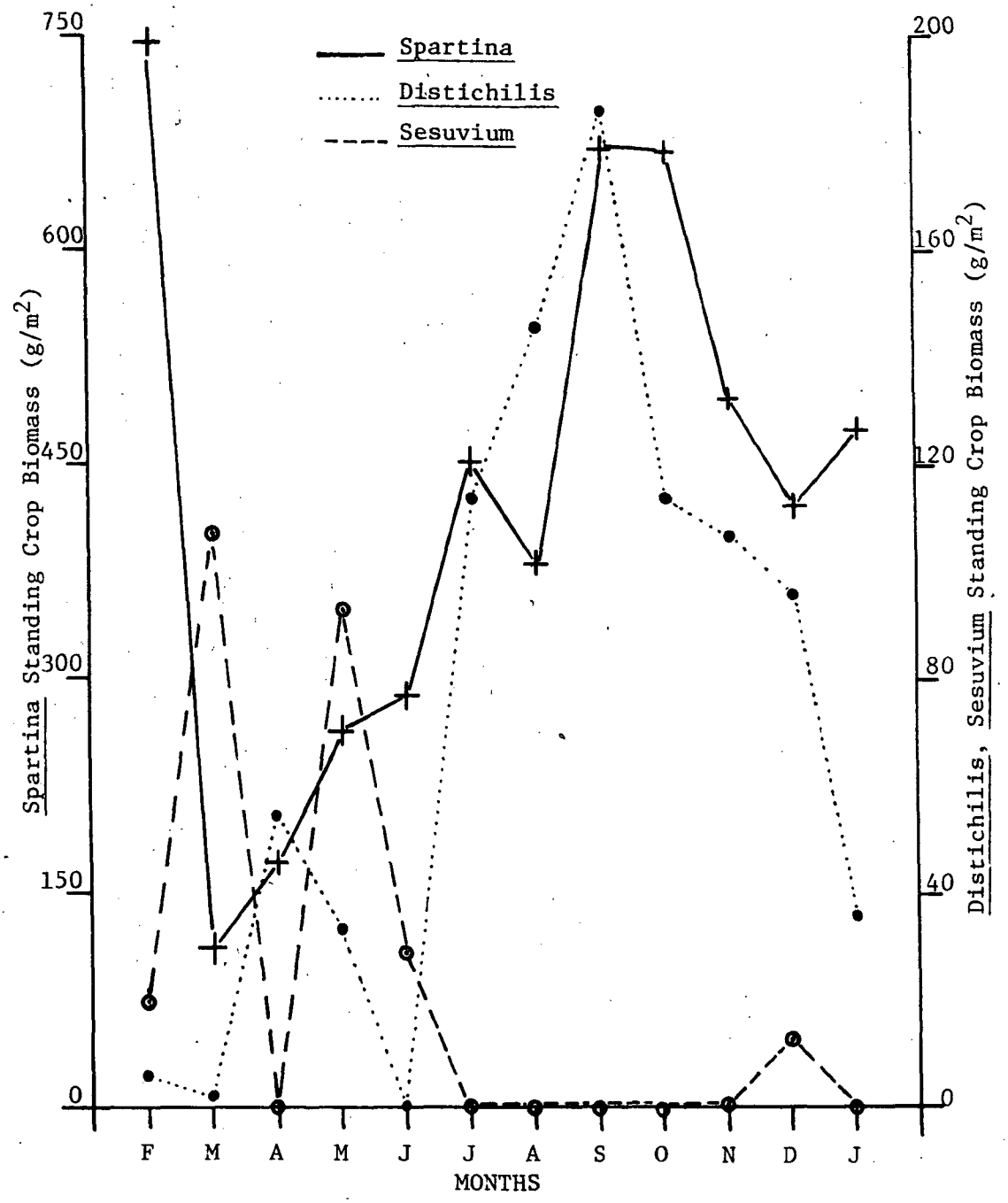
Standing Crop

At least two peak periods of standing crop biomass (SCB) were recognized for each of the species from both areas (Fig. 8 and 9). This supports the preceding analysis which indicated the existence of two high production periods. In contrast, other salt marsh studies found only one peak SCB at the end of the summer (usually in August and September) for various species of Spartina (Squiers and Good, 1974; Nixon and Oviatt, 1973; Wass and Wright, 1969; and Williams and Murdoch, 1969). However, these studies were much farther north, e.g., in North Carolina and New Jersey.

S. bakerii had a high living SCB estimate in February and reached a major peak in September and October (Fig. 8). A minimum standing crop estimate was found in March and estimates of SCB increased steadily from March until September.

In the SPD area, D. spicata showed two peaks for SCB (Fig. 8). Maximum green standing crop biomass occurred in September, 1974 and another smaller peak was observed in April, 1974. Sesuvium portulacastrum's peak living SCB was attained in March, 1974 with a slightly lower value in May.

Fig. 8. Living standing crop of the plants harvested on the SPD area of a Merritt Island, Florida salt marsh between February, 1974 and February, 1975.



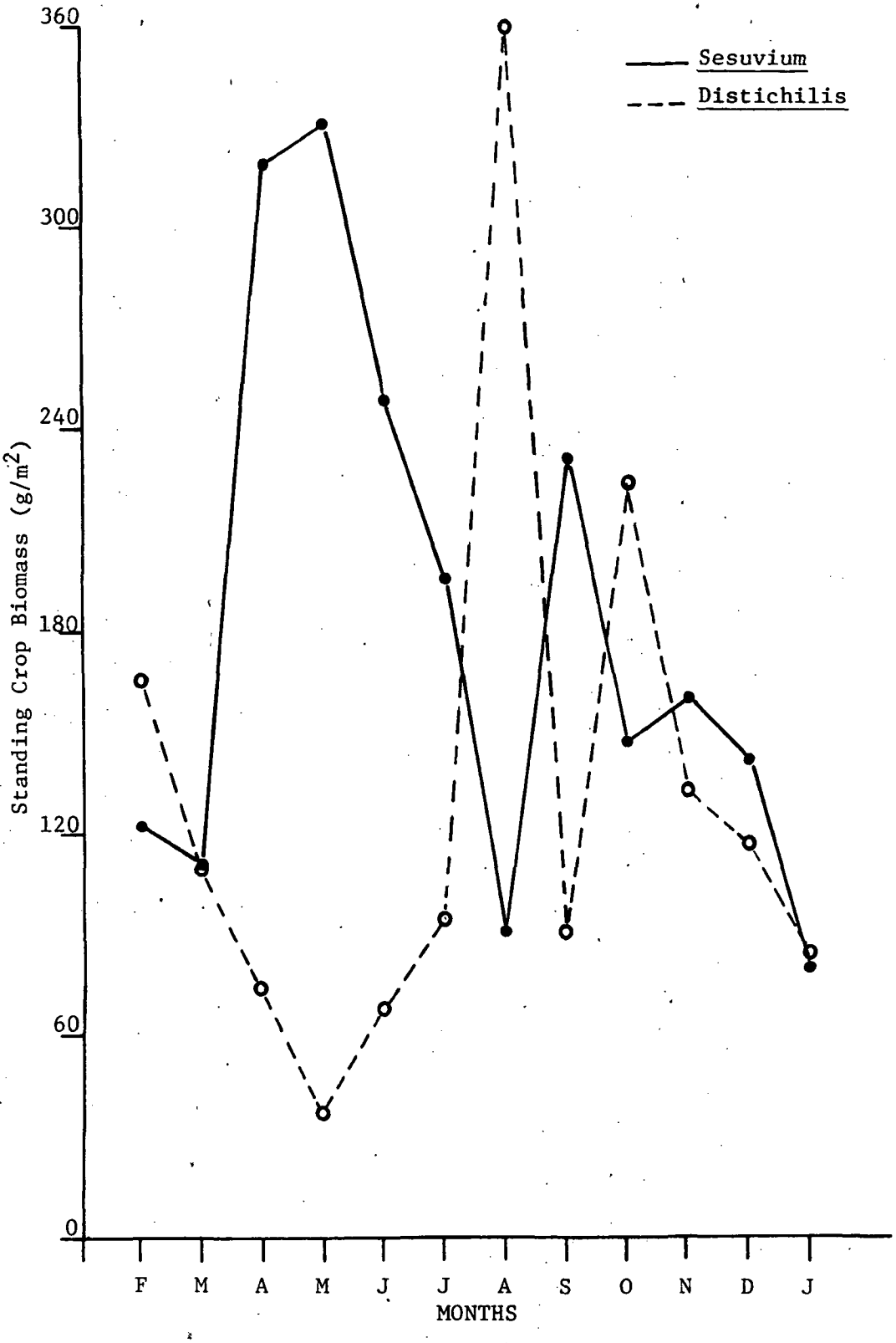


Fig. 9. Living standing crop of the plants harvested on the DS area of a Merritt Island, Florida salt marsh between February, 1974 and February, 1975.

The dominant plants found on the SPD area were revealed to achieve maximum growth at two or more times during the year. These accelerated periods of growth may be synchronized to allow for optimum usage of available sources of energy and nutrients by the coexisting species. For example, by July it appeared shading and other forms of competitive activities by S. bakerii may have reduced the standing crop of Sesuvium (Fig. 8). The Sesuvium reappeared in November after peak growth periods for Spartina and Distichilis. The March to April gain in SCB for Sesuvium on the DS area was 210 g (Fig. 9). Peak standing crop occurred in May. A steady decline followed the early summer peak and ended in August. Peak standing crop values for D. spicata in the DS area were concomitant with low standing crop values for S. portulacastrum.

Standing crop estimates for dead material appeared to be correlated with standing crop biomass of living in all cases except Sesuvium on the SPD and DS areas (Figs. 8, 9, 10, 11).

Distichilis spicata had a high standing crop biomass (live) of 360 g/m^2 in August, 1974 with two smaller peaks appearing in February and October (Fig. 9). Sesuvium on the same area was nearly an inverse image of the Distichilis with its high value occurring in May (330 g/m^2) and two smaller peaks in September and November. Average standing crop values for dominant species of plants ranged between 130.90 g/m^2 for Sesuvium (Table 7) to 429.08 g/m^2 dry weight for the S. bakerii. Dead standing crop ranged between 44.82 and 699.05 g/m^2 for Sesuvium and S. bakerii respectively. Standing crop biomass values for D. spicata were 211.32 for living and 438.32 g/m^2 for dead.

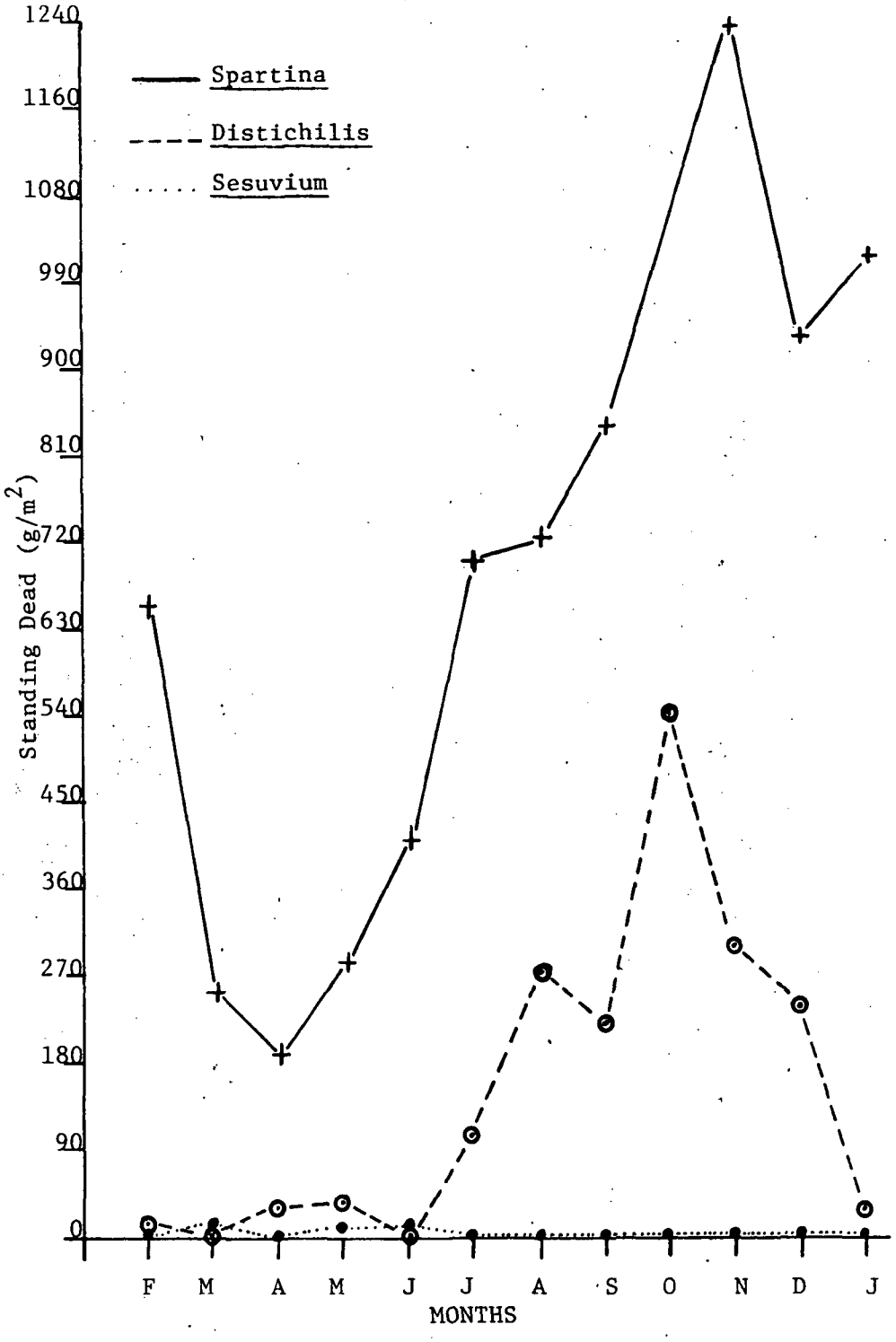


Fig. 10. Standing dead of the plants harvested in the SPD area of a Merritt Island, Florida salt marsh between February, 1974 and February, 1975.

Fig. 11. Standing dead of the plants harvested in the DS area of a Merritt Island, Florida salt marsh between February, 1974 and February, 1975.

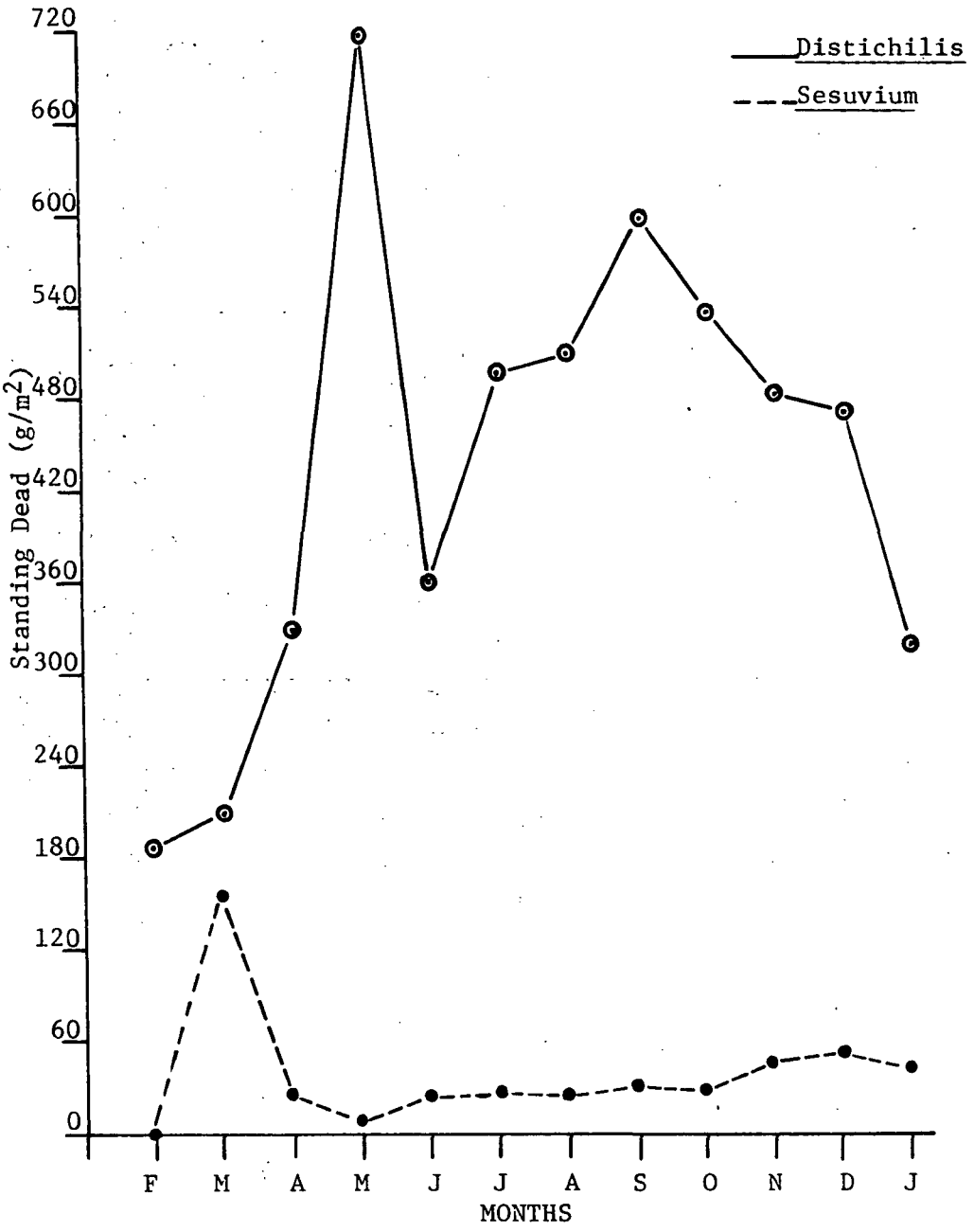


Table 7. Overall means for the standing crop biomass values of three species of plants for the SPD and DS habitats are listed for the salt marsh on Merritt Island, Florida. Plants were collected and biomass estimates were taken for the period of February, 1974 to February, 1975.

Area	Species	Dry Weight (g/m^2)	Dead Weight (g/m^2)
SPD	Spartina	429.08 (0.465[a])	699.05 (0.498)
SPD	Distichilis	74.07 (0.828)	156.77 (1.032)
SPD	Sesuvium	29.36 (1.404)	10.40 (1.023)
DS	Distichilis	211.32 (0.687)	438.32 (0.360)
DS	Sesuvium	130.90 (0.666)	44.82 (0.871)

[a]Coefficient of variation appears in parentheses.

These figures were quite comparable to those of Wass and Wright (1969) who had an SCB value of 360.00 g/m^2 (Table 8), but quite different from the results of Gabriel and de la Cruz (1974).

Squiers and Good (1974) reported slightly lower values for dead-SCB. In May short S. alterniflora peaked at 240 g/m^2 and in July tall S. alterniflora yielded 300 g/m^2. Differences among SCB values reported in the literature and my results were undoubtedly due to specific environmental conditions peculiar to the area from which the plant species were obtained.

Caloric Values

Listed in Table 9 are the mean caloric values for each of the species of concern. Values appear as both calories per gram and as calories per gram of ash-free dry weight (AFDW). The AFDW values were corrected by an average ash-free quantity encompassing the whole year's collection of a particular plant species (Table 10). Variation between means was not decreased with this averaging process as were the values for Squiers and Good (1974) who determined ash values for each species for each month that samples were taken. Golley (1961) reported considerable variation in ash content of plants from old fields, grasslands and salt marshes.

A great deal of variation occurred between monthly caloric values (Table 11). For example S. bakerii ranged from 3642 cal/g in June to 4498 cal/g in December (Fig. 12). In the DS area Distichilis spicata changes in energy content from a low of 3630 cal/g in September to 5511 cal/g in December (Fig. 13). Sesuvium portulacastrum in the DS area varied from a low of 2918 cal/g in June to a high of 4013

Table 8. Standing crop biomass estimates of various species of *Spartina* and *Distichilis spicata* as indicated in the literature. Data are in $g \cdot m^{-2} \cdot yr^{-1}$.

Author(s)	Date(s)	*Spartina* sp.	*Distichilis spicata*
Morgan	1961	413[a]	-
Ranwell	1961,1964	700-1060[b]	-
Good	1965	300[a]	-
Williams & Murdoch	1966	250-2100[a]	-
Waits	1967	640[c]	-
Stroud & Cooper	1969	259-1320[a]	-
Udell et al.	1969	827[a]	-
Wass & Wright	1969	1332[a] 1456[d]	360 -
Williams & Murdoch	1969	545[a]	-
Keefe & Boynton	1973	482-634[a]	-
Good	1972[f]	1600[a]	-
Johnson	1970[f]	1207	-
Nixon & Oviatt	1973	432-840[a] 430[c]	- -
Gabriel & de la Cruz	1974	-	45
Present Study	1975	429[e]	211

[a] *Spartina alterniflora*; [b] *S. townsendii*; [c] *S. patens*; [d] *S. cynosuroides*; [e] *S. bakerii*.
[f] From Nixon and Oviatt (1973).

Table 9. Mean caloric values of three species of plants from the SPD and DS habitats of a salt marsh on Merritt Island, Florida. Caloric values were determined for the period of February, 1974 to February, 1975.

Area	Species	Calories/g	Calories/AFDW
SPD	Spartina	4088.78 (0.079[a])	4362.40 (0.081)
SPD	Distichilis	4130.18 (0.099)	4350.57 (0.098)
SPD	Sesuvium	3878.53 (0.092)	6439.42 (0.089)
DS	Distichilis	4275.10 (0.117)	4493.37 (0.118)
DS	Sesuvium	3310.17 (0.129)	5023.26 (0.130)

[a]Coefficient of variation appears in parentheses.

Table 10. Ash content of the dominant species of plants of the SPD and DS areas. Plants were collected from a Merritt Island, Florida salt marsh between February, 1974 and February, 1975. Ash content was used to calculate ash-free dry weight (AFDW) caloric values.

Area	Species	Average Ash Content (%)	Standard Error
SPD	Spartina	6.125	0.070
SPD	Distichilis	5.249	0.034
SPD	Sesuvium	28.312	0.047
DS	Distichilis	4.880	0.102
DS	Sesuvium	26.179	0.011

Table 11. Caloric values determined on a dry weight basis. Determinations were made on dominant plant species of the SPD and DS areas of a Merritt Island, Florida salt marsh. Plants were collected between February, 1974 and February, 1975.

	Calories/g				
	SPD			DS	
Month	Spartina	Distichilis	Sesuvium	Distichilis	Sesuvium
February	3938.11	*******[a]	3285.75	4615.91	3093.29
March	4103.58	3819.48	3667.70	3990.97	3227.47
April	3878.06	3550.18	*******	4054.71	2929.98
May	3713.64	4055.58	3783.96	3903.13	3221.16
June	3642.44	3772.72	4033.45	4075.66	2917.82
July	3803.52	3745.56	*******	4060.67	3331.17
August	3658.65	5083.61	3801.63	3903.58	3545.00
September	4190.37	4553.55	4442.96	3629.76	3796.89
October	4199.84	4554.09	*******	4489.69	3598.88
November	4364.43	*******	3779.94	4493.62	3502.52
December	4498.07	4434.24	4232.87	5511.26	4012.52
January	4277.96	4732.74	*******	4572.30	3614.23

[a]Species were not found in the sample.

Fig. 12. Caloric values of plant materials collected from the SPD area between February, 1974 and February, 1975 on a Merritt Island, Florida salt marsh.

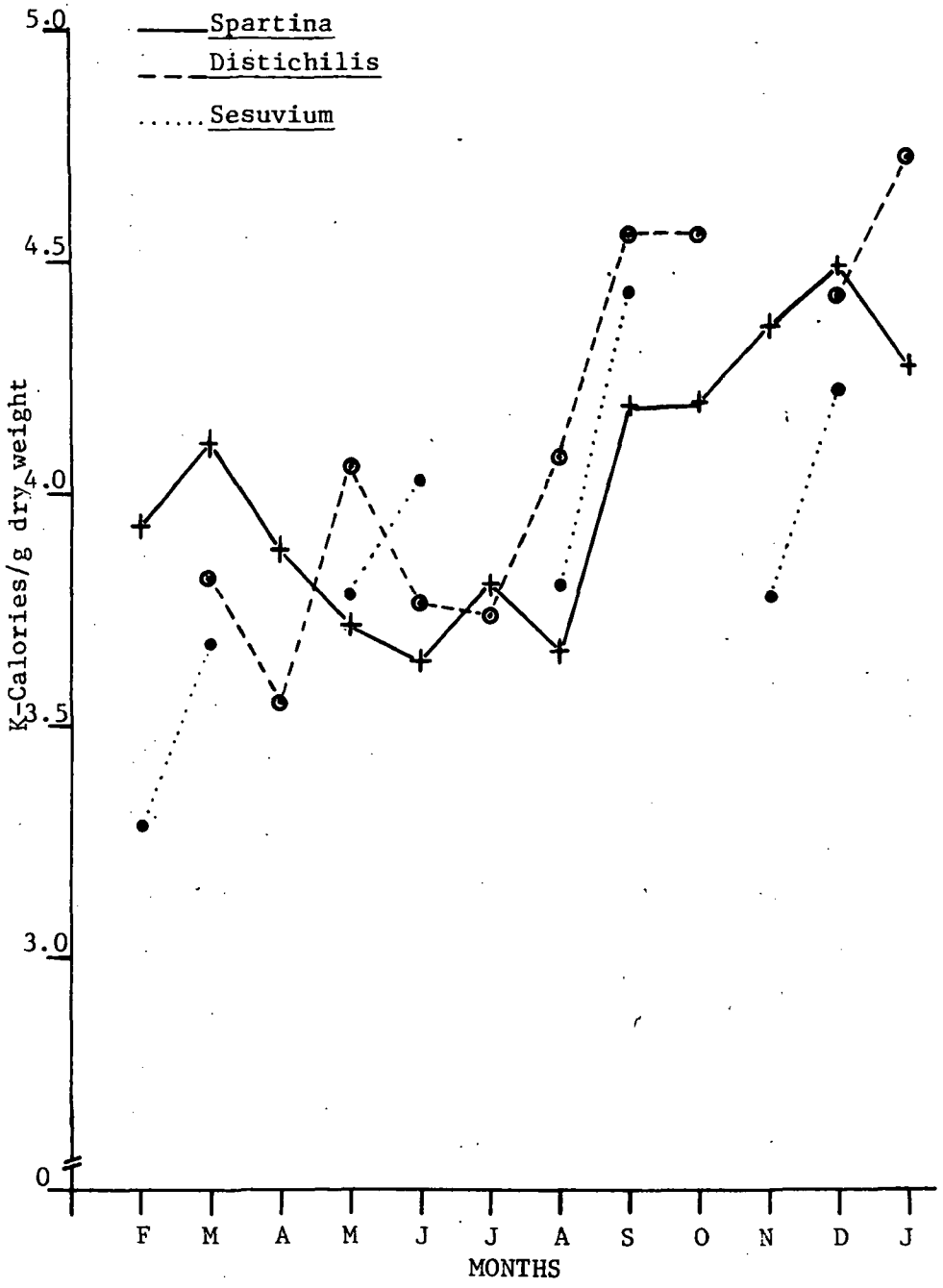
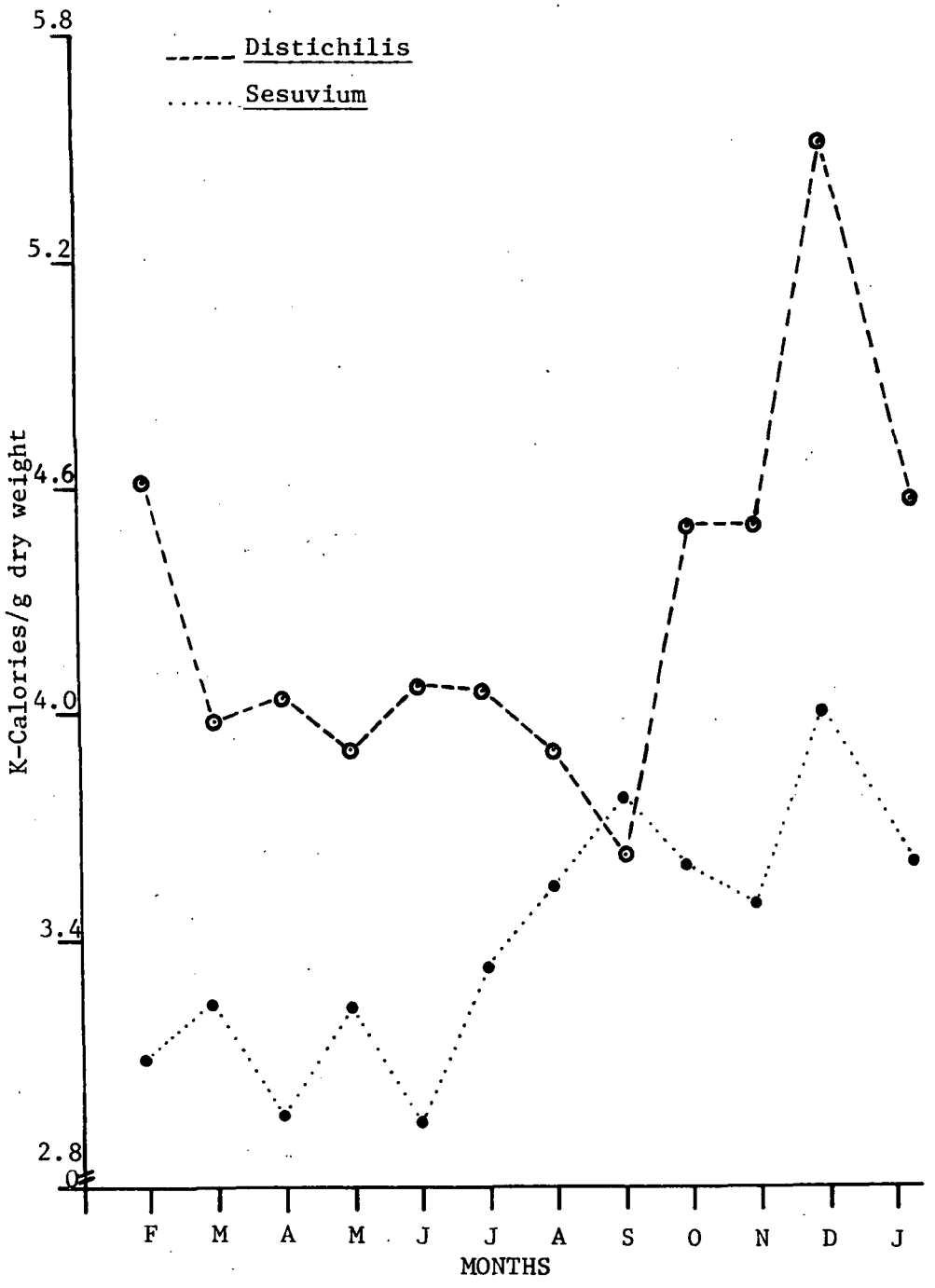


Fig. 13. Caloric values of plant materials collected from the DS area on a Merritt Island, Florida salt marsh between February, 1974 and February, 1975.



cal/g in December.

Average ash content obtained in my study was less than 5% in Distichilis and over 28% in Sesuvium (Table 10). No ash values were discovered in the literature for either Distichilis or Sesuvium. Likewise, no values for ash content of Spartina bakerii were found in the literature; however, Squiers and Good (1974) reported ash values for different populations of Spartina alterniflora as 9.54 and 14.74%. Keefe and Boynton (1973) provided a range of values for ash content of short S. alterniflora (16.2 - 26.2%), short S. alterniflora plus Distichilis spicata (18.0 - 33.4%), short S. alterniflora plus tall S. alterniflora (22.2 - 48.2%), respectively. Boyd (1971) gave ash values of between 3 and 5% for Juncus effusus. Van Hook (1971) reported ash values between 3.4 and 10.76% for a mixture of Festuca and Andropogon.

Summarized in Table 12 are the caloric values (AFDW) determined by species, month, and community. Caloric values of D. spicata from Gabriel and de la Cruz (1974) averaged 4654 cal/AFDW. My values averaged 4493.37 cal/AFDW for that same species (Table 9, 12). Giant cordgrass (S. cynosuroides) was recorded to have a caloric value of 4597 cal/AFDW (op cit). My data indicated a value for S. bakerii of 4362.4 cal/AFDW (Table 9, 12). Golley (1959) reported a value of 4076.00 cal/AFDW for an unspecified type of Spartina.

Considerable variation in cal/AFDW is shown for the species (Figs. 14, 15). This variation was undoubtedly in part the result of changes in ash content of the plants. However, the data are not available to document this supposition. Recall, the AFDW correction

Table 12. Caloric values determined on an ash-free dry weight basis. Caloric determinations were made on dominant plant species of the SPD and DS areas of a Merritt Island, Florida salt marsh. Plants were collected between February, 1974 and February, 1975.

	Calories/AFDW				
	SPD			DS	
Month	Spartina	Distichilis	Sesuvium	Distichilis	Sesuvium
February	4194.84	*******[a]	5582.59	4858.60	4665.22
March	4371.05	4044.29	6214.96	4201.56	5244.00
April	4134.99	3750.89	*******	4262.73	4582.40
May	3958.27	4285.59	6546.69	4103.37	5238.76
June	3879.89	3978.93	6325.68	4309.45	4309.45
July	4053.50	3958.81	*******	4268.99	5134.88
August	3897.21	4312.40	6107.65	4029.18	5388.40
September	4463.54	4806.56	7286.52	3823.51	5567.01
October	4473.62	4806.44	*******	4723.07	5239.13
November	4656.40	******	6236.89	4728.15	5168.14
December	4804.22	4556.38	7214.24	5800.98	6099.02
January	4557.63	5005.75	*******	4810.82	5443.01

[a]Species were not found in the sample.

Fig. 14. Ash-free dry weight caloric values of plant materials collected from the SPD area on a Merritt Island, Florida salt marsh between February, 1974 and February, 1975.

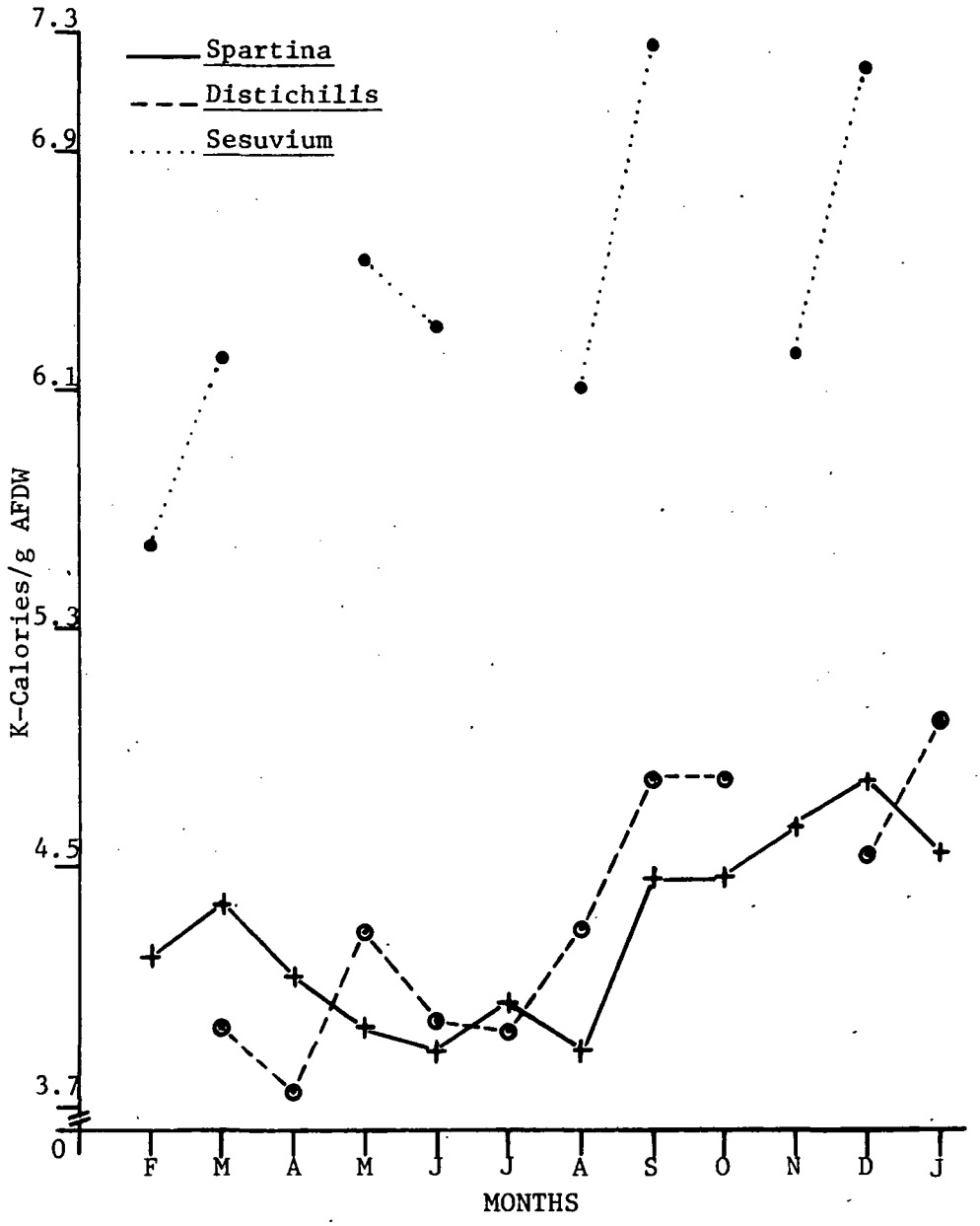
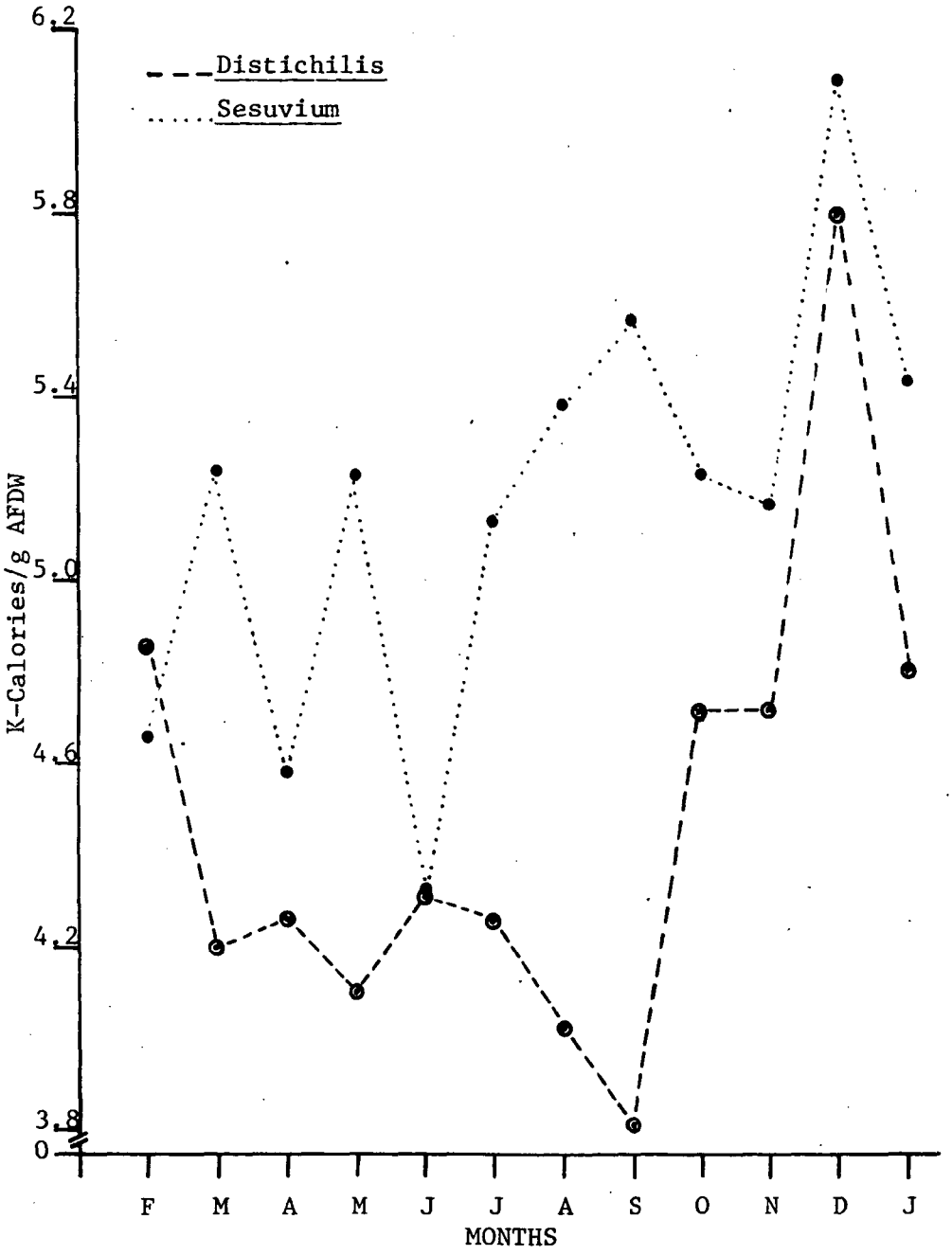


Fig. 15. Ash-free dry weight caloric values of plant materials collected from the DS area on a Merritt Island, Florida salt marsh between February, 1974 and February, 1975.



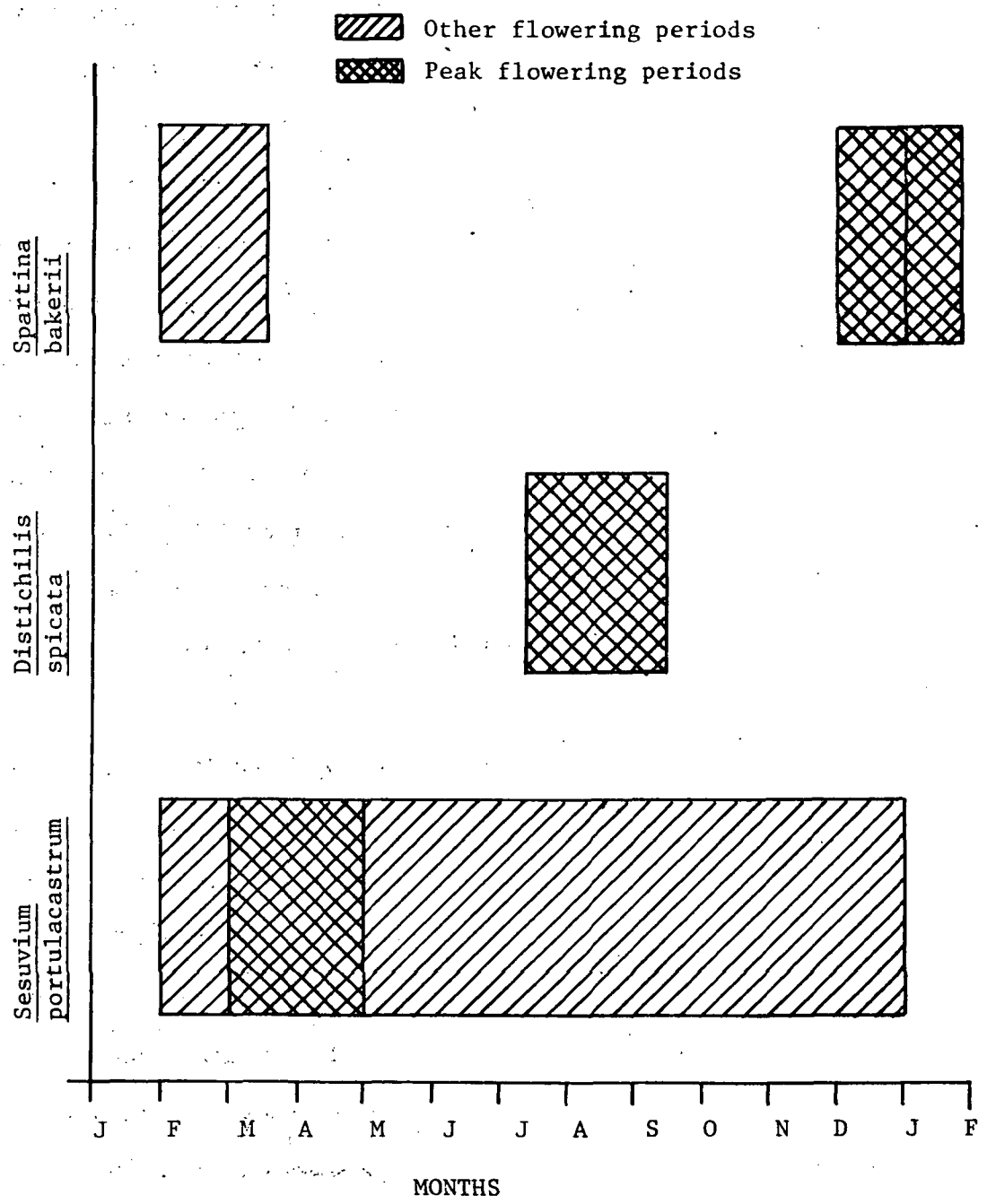
factor is based on a yearly average and not a seasonal or montly one. Boyd (1971) found little seasonal fluctuation for values of Juncus effusus (between 4328 and 4546 cal/AFDW). Van Hook (1971) found an average of 4782/cal/AFDW with a seasonal fluctuation of approximately 400 cal/AFDW in a grassland community.

There appeared to be a seasonal fluctuation in caloric values for all species investigated. Highest values occurred in the latter portions of the year after a slight downward trend in January. This increase in caloric content appears as early as July, 1974 in Sesuvium sp and continued into fall and winter (Fig. 15). Caloric values declined sharply at the first of the year with the beginning of a dry season. This sudden decline may be explained by underground storage, low nutrient availability, increased seed dispersal, or initiation of a new period of higher production.

Phenology

An indicator of the unique adaptations of these plants was the timing of their sexual reproduction. This important process would be expected to occur while competitive pressure from other species is low and energy cost does not place the species at a disadvantage. Indicated in Fig. 16 is evidence that the reproductive periods of each of the species were only slightly overlapping. Spartina bakerii started flowering the last of December and continued into January and February. Some seed dispersal occurred in March. Distichilis spicata and Sesuvium portulacastrum, which are nearly preempted by Spartina in the SPD area, seem to complement each other in the DS area. Sesuvium is more commonly found growing in panne areas where

Fig. 16. Phenological data concerning the flowering periods of the principle plant species of a Merritt Island, Florida salt marsh collected between February, 1974 and February, 1975. Observations were made in the field.



salt concentrations are obviously too high for Distichilis. Distichilis and some of the other grasses, such as Paspalum, reproduce beginning in late July and end in early September. Sesumium overlaps somewhat with the reproductive period of the S. bakerii, but begins its major reproductive effort in March as Spartina has just finished and continues into late April and early May. With the exception of January and February, Sesuvium reproduces continually, in contrast to the grasses which seem to have flowered only once during the year. Each of the grasses studied also have rhizomatous reproduction. In comparison, other authors found S. alterniflora and D. spicata to sexually reproduce only once in late summer. Nixon and Oviatt (1973) recorded the blooming and seeding of S. alterniflora between July and September. Cameron (1972) studied an area vegetated with S. foliosa which bloomed between August and October.

Macroinvertebrates

During the period of August, 1974 through January, 1975, a total of 79 families of macroinvertebrates was collected from the soil and aerial portions of the SPD and DS areas on the Merritt Island salt marsh. Forty of these were collected exclusively from the aerial stratum, 20 from the soil, and 19 were found in both the soil and the foliage. Including those organisms which were not definitely identified (as to family), there were 18 orders of organisms represented. Table 13 lists the organisms collected which have been separated into trophic categories (Borror and DeLong, 1964). Community structure is further defined in Table 14. Common families of both the soil and aerial layers consisted of saprovores and omnivores

Table 13. A list of the macroinvertebrates collected from the salt marsh ecosystem on Merritt Island, Florida from August, 1974 to February, 1975. Collections include organisms from the soil and herb stratum of SPD and DS communities. All organisms were identified to the family level. "A" refers to aerial and "S" refers to soil.

Predators	Herbivores	Saprovores & Others
Araneida	Collembola	Collembola
Uloboridae A	Poduridae S	Undetermined S
Dictynidae A	Isotomidae S	Orthoptera
Gnaphosidae AS	Orthoptera	Blattellidae AS
Clubionidae A	Tetrigidae A	Blaberidae A
Anyphaenidae A	Gryllidae A	Hemiptera
Ctenidae A	Thysanoptera	Undetermined S
Thomisidae A	Thripidae A	Coleoptera
Salticidae A	Hemiptera	Undetermined AS
Pisauridae A	Lygaedae AS	Pselaphidae S
Lycosidae AS	Homoptera	Erotylidae S
Oxyopidae A	Cicadellidae A	Tenebrionidae S
Araneidae A	Cercopidae A	Anobiidae A
Linyphidae AS	Delphacidae A	Scolytidae S
Odonata	Margarodidae A	Trichoptera
Libellulidae A	Diaspididae A	Hydroptilidae A
Coenagrionidae A	Pseudococcidae S	Diptera
Thysanoptera	Coleoptera	Undetermined AS
Phlaeothripidae A	Chrysomelidae A	Tipulidae AS
Hemiptera	Diptera	Psychodidae S
Naucoridae A	Tephritidae S	Culicidae A
Nabidae A	Coelopidae A	Ceratopogomidae AS
Gelastocoridae S	Drosophilidae S	Simuliidae A
Hydrometridae A		Tabanidae S
Mesoveliidae A		Chironomidae AS
Coleoptera		Sciaridae A
Carabidae AS		Otitidae A
Dytiscidae S		Calliphoridae A
Gyrinidae S		Hymenoptera
Staphylinidae S		Formicidae AS
Hydrophilidae S		Amphipoda
Diptera		Undetermined AS
Chaoboridae S		Isopoda
Cecidiomyiidae AS		Undetermined S

Table 13. Continued.

Predators	Herbivores	Saprovores & Others
Empidae AS		Polyxenida
Dolichopididae AS		Polyxenidae A
Phoridae AS		Acari
Hymenoptera		Undetermined AS
Eulophidae A		Stylommatophora
Encyritidae A		Undetermined AS
Proctotrupidae A		Annelida
Chelonethida		Undetermined S
Undetermined A		

Table 14. The percentage of the total number of organisms and the total number of species for each of the trophic groups are listed in parts A and B. Calculations were made from data gathered on organisms collected on a Merritt Island, Florida salt marsh between August,1974 and February, 1975.

		A. Percentage of Total Numbers		
Area	Stratum	Predators	Saprovores and Others	Herbivores
SPD	Soil	31.82	65.56	1.62
SPD	Foliage	24.37	60.20	15.41
DS	Soil	15.16	64.62	20.22
DS	Foliage	23.92	45.37	30.69

		B. Percentage of Total Species		
Area	Stratum	Predators	Saprovores and Others	Herbivores
SPD	Soil	45.61	47.37	7.02
SPD	Foliage	41.52	36.44	22.03
DS	Soil	38.36	56.16	5.48
DS	Foliage	39.84	36.84	23.30

such as the Blattelidae, Formicidae, Chironomidae, and Ceratopogomidae. Herbivorous invertebrates had only one representative family common to both the soil and aerial samples, Lygaedae. Predators had a number of families common to both the collections, and several families from the order of Araneida and Diptera made up the bulk of their representatives.

Cameron (1972) comparing two different marsh communities (Salicornia and Spartina) found a total of 103 species of adult invertebrates, comprising 11 orders and 52 families. The most numerous orders were Diptera, Coleoptera, and Hymenoptera (54% of the species). Wiegert (1974) found 94-97% of his soil and litter invertebrates to be Acarina and Collembola.

Numbers of Soil Invertebrates

Summarized in Table 15 are the data on macroinvertebrate collections from the soil. The number of soil organisms appeared to increase throughout the course of study (Fig. 17). On the SPD area saprovores were the most dynamic group while the herbivores remained fairly constant throughout the entire 6-month period (Fig. 18). However, a large increase in numbers of herbivores was indicated in January in the DS community (Fig. 19). Hatching and emergence of young largely into the larval and numphal stages in the soil accounts for part of this increase. In both the SPD and DS areas, saprovores increased substantially from October to December, 1974. These increases were undoubtedly related to significant increases in dead SCB recorded for this period in the SPD area (Fig. 10).

Table 15. Macroinvertebrates collected from the soil of SPD and DS areas. The soil sampler had a capacity of 327 cc. Samples were taken from a salt marsh on Merritt Island, Florida between August, 1974 and February, 1975.

Area	Month	Sample Size	Total		Larvae		Adults		Nymphs	
			No. Individuals	No. Taxa	No. Individuals	No. Taxa	No. Individuals	No. Taxa	No. Individuals	No. Taxa
SPD	August	5	0	0	0	0	0	0	0	0
DS	August	5	4	5	1	1	0	0	3	4
SPD	September	5	9	7	6	4	2	2	1	1
DS	September	5	27	12	14	8	4	4	9	4
SPD	October	5	1	1	0	0	1	1	0	0
DS	October	5	4	3	3	2	1	1	0	0
SPD	November	5	94[a]	16	81	6	8	7	3	3
DS	November	5	50	12	38	5	6	5	6	2
SPD	December	5	115[a]	19	82	5	21	8	9	6
DS	December	5	65[a]	19	31	5	16	8	17	6
SPD	January	5	126	21	22	4	39	11	65	6
DS	January	5	89[a]	19	53	7	22	8	9	4

[a]These values also include pupae.

Fig. 17. Overall numbers of soil macroinvertebrates collected from the SPD and DS areas on a Merritt Island, Florida salt marsh between August, 1974 and February, 1975. Numbers are for a volume of 327 cc; to obtain numbers/m^3 multiply by 1,553.0.

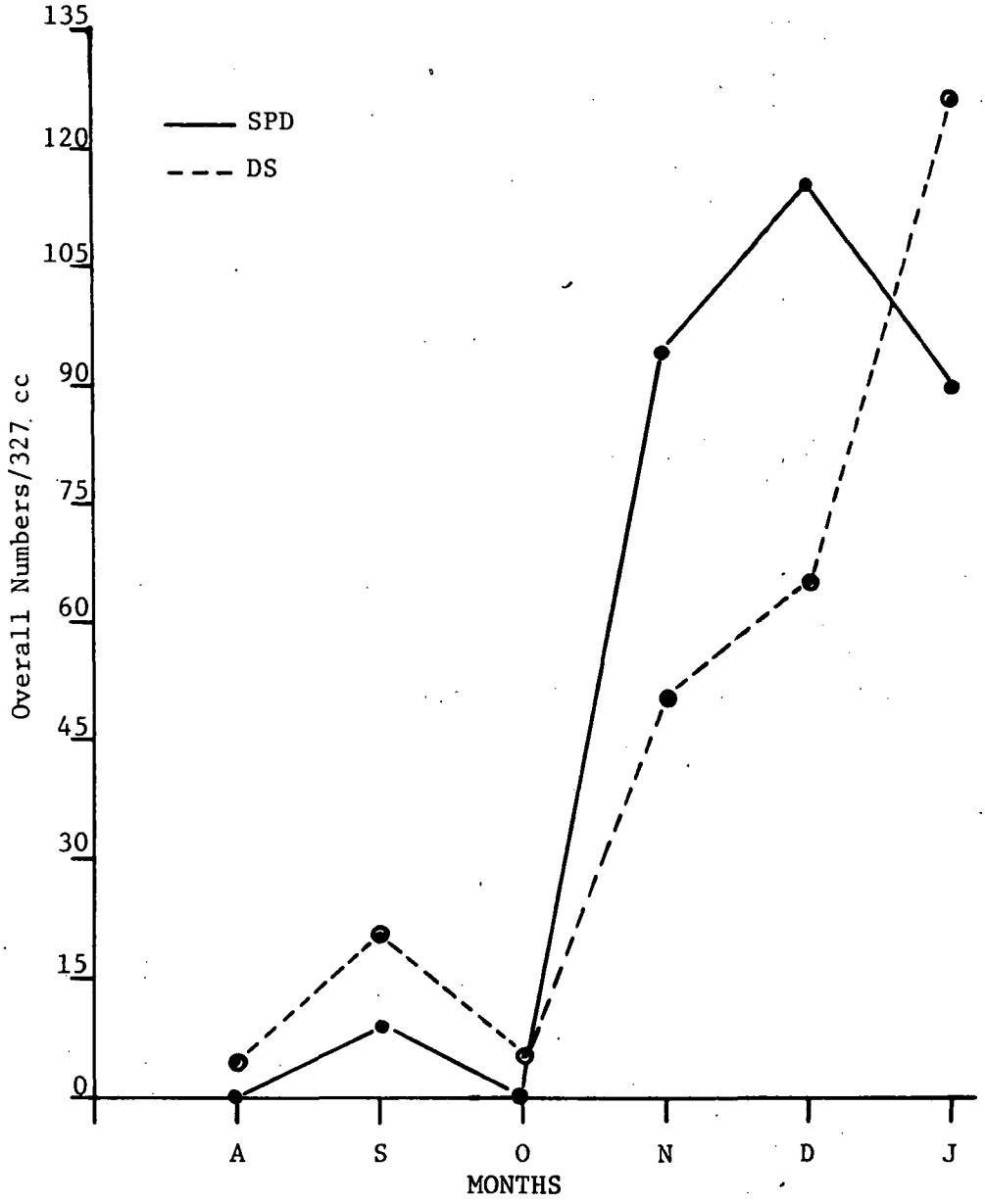


Fig. 18. Numbers of soil macroinvertebrates for each trophic level collected from the SPD area on a Merritt Island, Florida salt marsh between August, 1974 and February, 1975. Numbers are for a volume of 327 cc; to obtain numbers/m^3 multiply by 1,553.0.

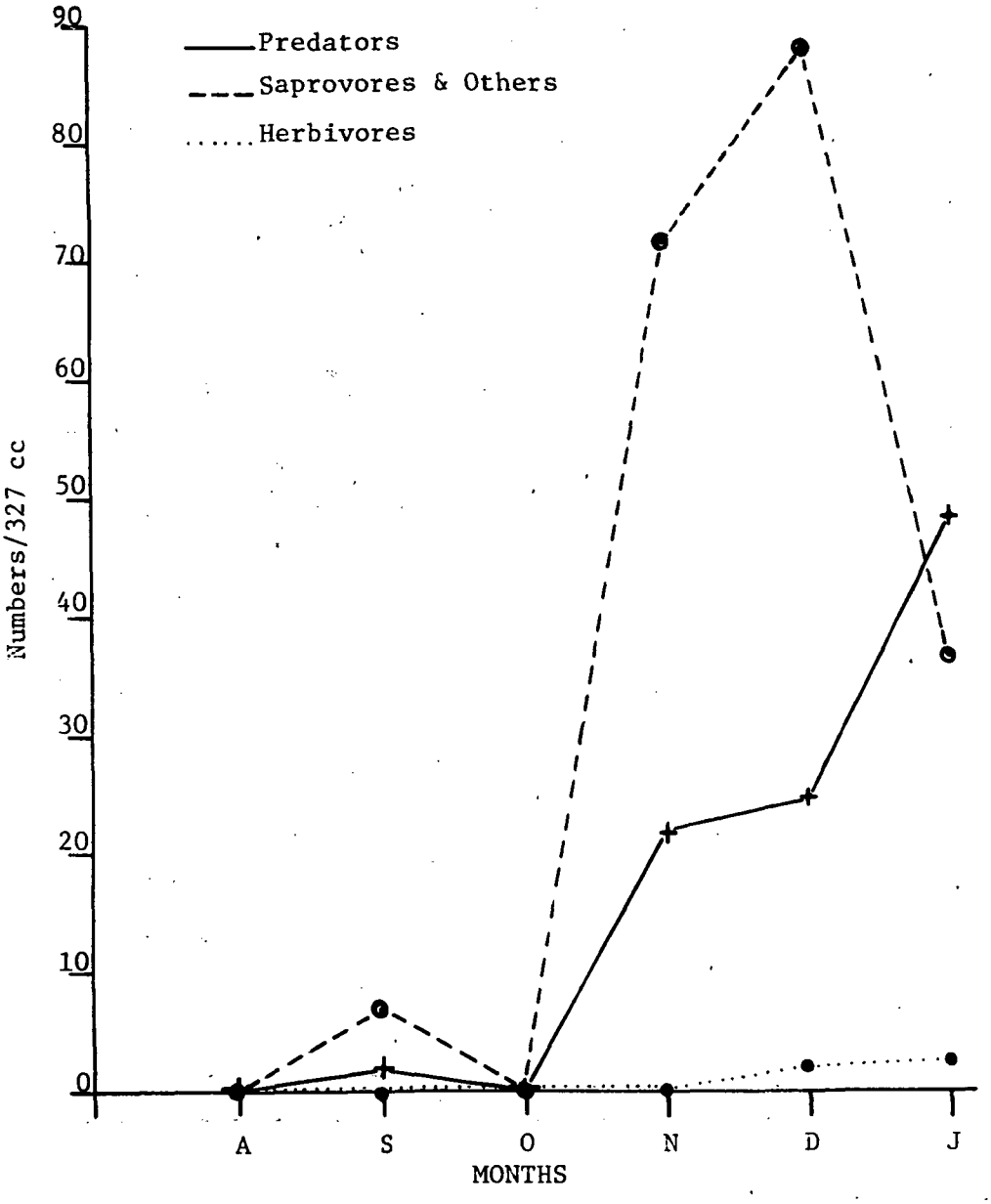
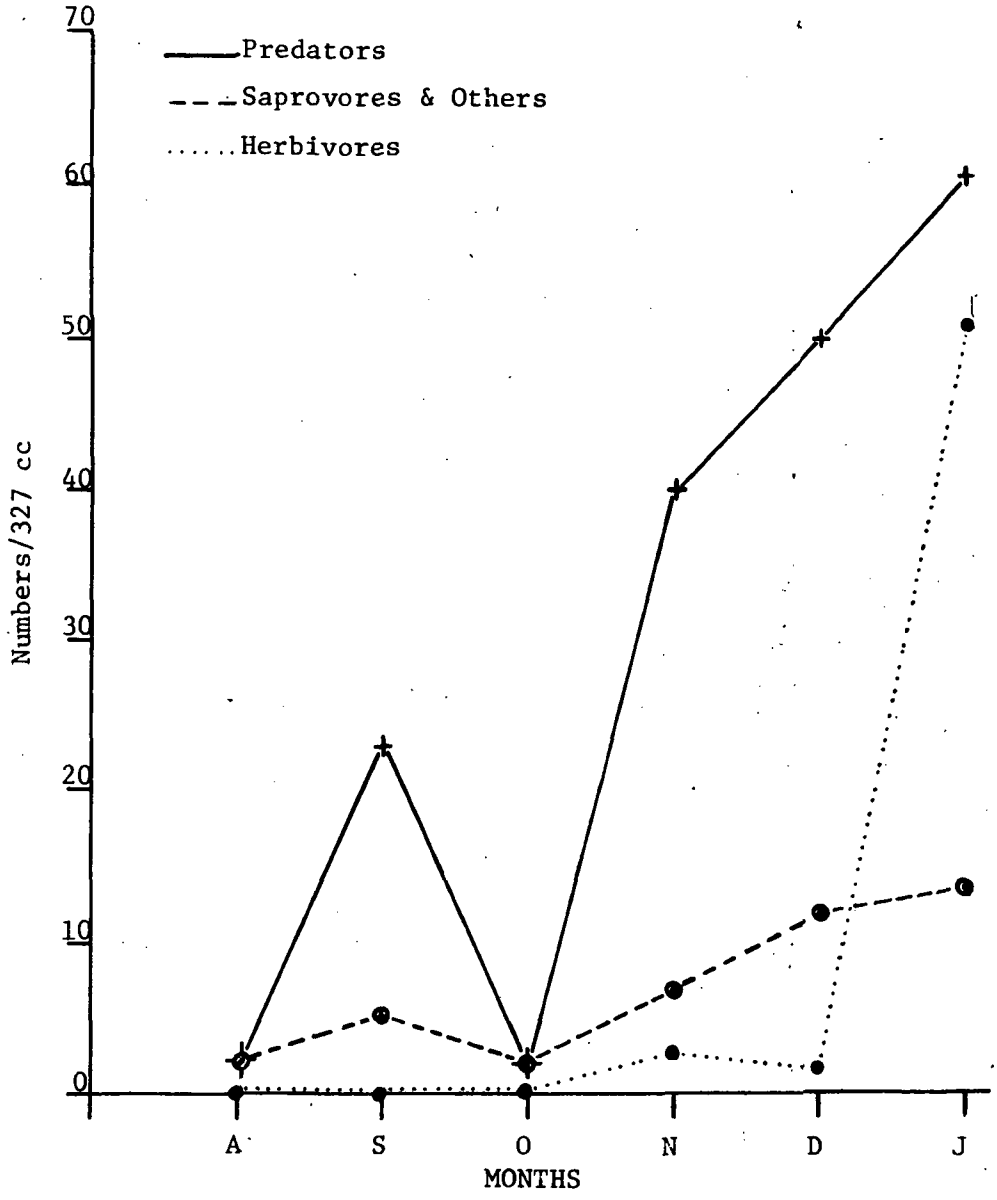


Fig. 19. Numbers of soil macroinvertebrates for each trophic level collected from the DS area on a Merritt Island, Florida salt marsh between August, 1974 and February, 1975. Numbers are for a volume of 327 cc; to obtain numbers/m^3 multiply by 1,553.0.



Increases in predator density lagged somewhat behind increases in other trophic groups (Fig. 18) or were not correlated as in **Fig.** 19. In October, 1974, soil invertebrate densities dropped to nearly zero after a long period of inundation resulting from a tropical depression. Although local population probably did not go to extinction at this time, sampling techniques were not sensitive enough to indicate more than a few or no individuals present. Populations recovered rapidly, however (Figs. 18, 19).

Numbers of Foliage Invertebrates

Numbers of organisms by life stage, study area, and sample date are given in Table 16. Overall numbers of organisms in the SPD area fluctuated considerably more than in the DS area (Fig. 20). A possible explanation was offered by Davis and Gray (1966) who claimed the dense cover of a Distichilis area provided superior protection from environmental hazards in contrast to the more open Spartina community. Cameron (1972) found fluctuations in invertebrate richness and diversity to be much lower and weeks later in appearance when compared to the findings of my study.

Illustrated in Fig. 21 are the changes in numbers in foliage macroinvertebrates on the SPD area. Numbers of predators and herbivores were found to fluctuate together. Whereas, saprovores reached a peak in October. Data given in Table 16 showed this increase to be almost exclusively adult organisms. This increase may have resulted from immigration of adults following the tropical depression which decreased numbers to nearly zero in early October.

Numbers of macroinvertebrates on the DS area oscillated in a

Table 16. Macroinvertebrates collected with a vacuum sampler from the foliage stratum of the SPD and DS areas. Organisms were obtained from an area of 0.132 m^2. Samples were taken from a salt marsh on Merritt Island, Florida between August, 1974 and February, 1975.

Area	Date	Sample Size	Total		Larvae		Adults		Nymphs	
			No. Individuals	No. Taxa	No. Individuals	No. Taxa	No. Individuals	No. Taxa	No. Individuals	No. Taxa
SPD	8-19-74	10	2	2	0	0	0	0	2	2
DS	8-19-74	10	30	11	1	1	12	7	17	3
SPD	9-15-74	10	92	27	0	0	52	14	40	13
DS	9-15-74	10	81	24	1	1	24	10	56	13
SPD	10-10-74	10	0	0	0	0	0	0	0	0
DS	10-10-74	10	51	15	1	1	22	6	28	8
SPD	10-23-74	10	160	15	0	0	131	5	38	10
DS	10-23-74	10	35[a]	5	0	0	20	4	14	1
SPD	11-08-74	10	57	16	0	0	24	5	33	11
DS	11-08-74	10	43[a]	17	1	1	29	9	13	7
SPD	12-03-74	10	40	15	0	0	25	6	15	9
DS	12-03-74	10	48	19	1	1	33	14	14	4
SPD	12-19-74	10	72[a]	17	0	0	49	7	20	10
DS	12-19-74	10	28	8	0	0	19	3	9	5
SPD	1-16-75	10	64	17	1	1	46	6	17	10
DS	1-16-75	10	57	21	1	1	37	12	19	8
SPD	1-25-75	10	35	18	3	2	20	7	12	9
DS	1-25-75	10	15	9	0	0	7	4	8	5

[a]These values also include pupae.

Fig. 20. Numbers of foliage macroinvertebrates collected on a Merritt Island, Florida salt marsh between August, 1974 and February, 1975. Numbers are for an area of 1.32 m^2; to obtain numbers/m^2 multiply by 0.758.

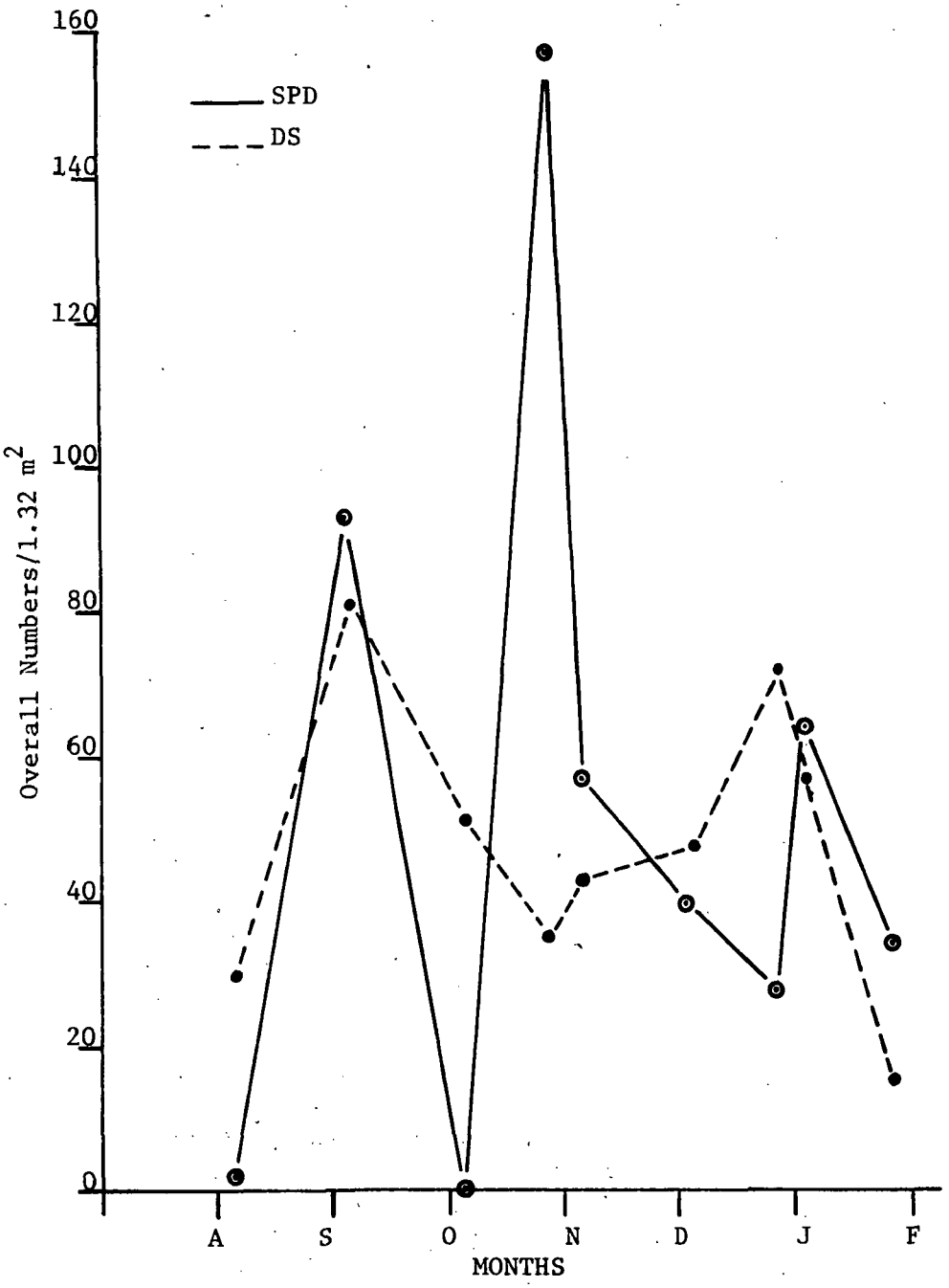
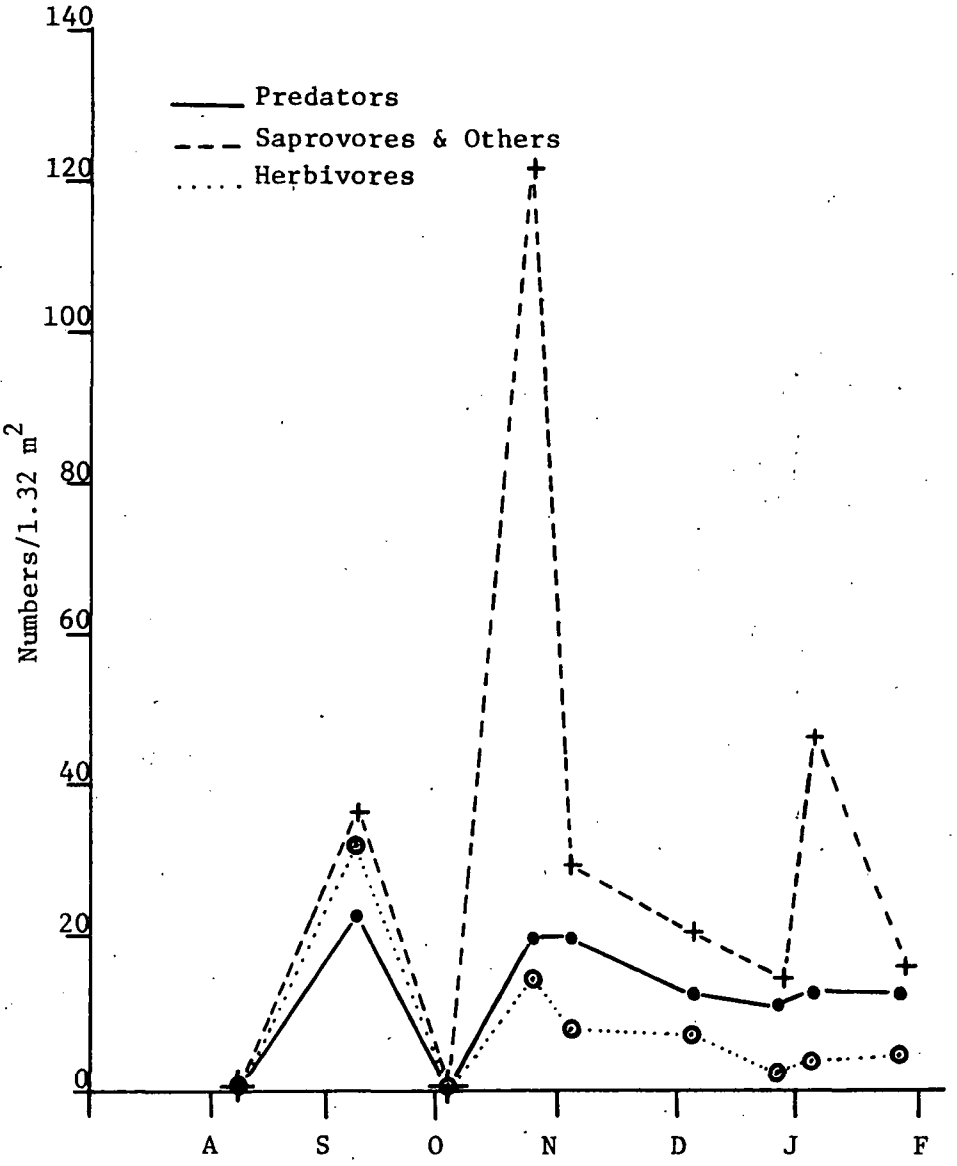


Fig. 21. Numbers of foliage macroinvertebrates for each trophic level collected from the SPD area on a Merritt Island, Florida salt marsh between August, 1974 and February, 1975. Numbers are for an area of 1.32 m^2; to obtain numbers/m^2 multiply by 0.758.



pattern similar to the SPD area (Fig. 22). However, the saprovores did not show a sudden increase in October as manifested on the SPD area (Fig. 21).

In contrast to the soil organisms, the abundance of predators among the foliage macroinvertebrates appeared to follow more closely the herbivore numbers (Figs. 21, 22). This may have indicated more dependence of the predators upon herbivores as opposed to saprovores in the soil samples.

Interactions among the trophic levels are further developed in later sections.

Species Diversity

Diversity of Soil Organisms

Species diversity (H') on the SPD area reached a maximum during December (3.4) with slightly smaller peaks in September (2.3) and January (3.2) (Fig. 23). Changes in diversity of the trophic groups were not always correlated. Diversity of soil organisms on the DS area ranged from a low of 1.5 in October to a high of 3.27 in December (Fig. 24). Variation in species diversity values on both areas probably reflected the changes in litter. Studies by Menhinick (1967) and Wiegert (1974) supported this interpretation. Both studies demonstrated that numbers of organisms increased in soil and litter owing to the added protection of the litter, which diminished extremes in heat and desiccation and increased food availability.

Changes in dominance (Simpson's Index, Si) among the soil organisms, for the two study areas are shown in Figs. 25 and 26.

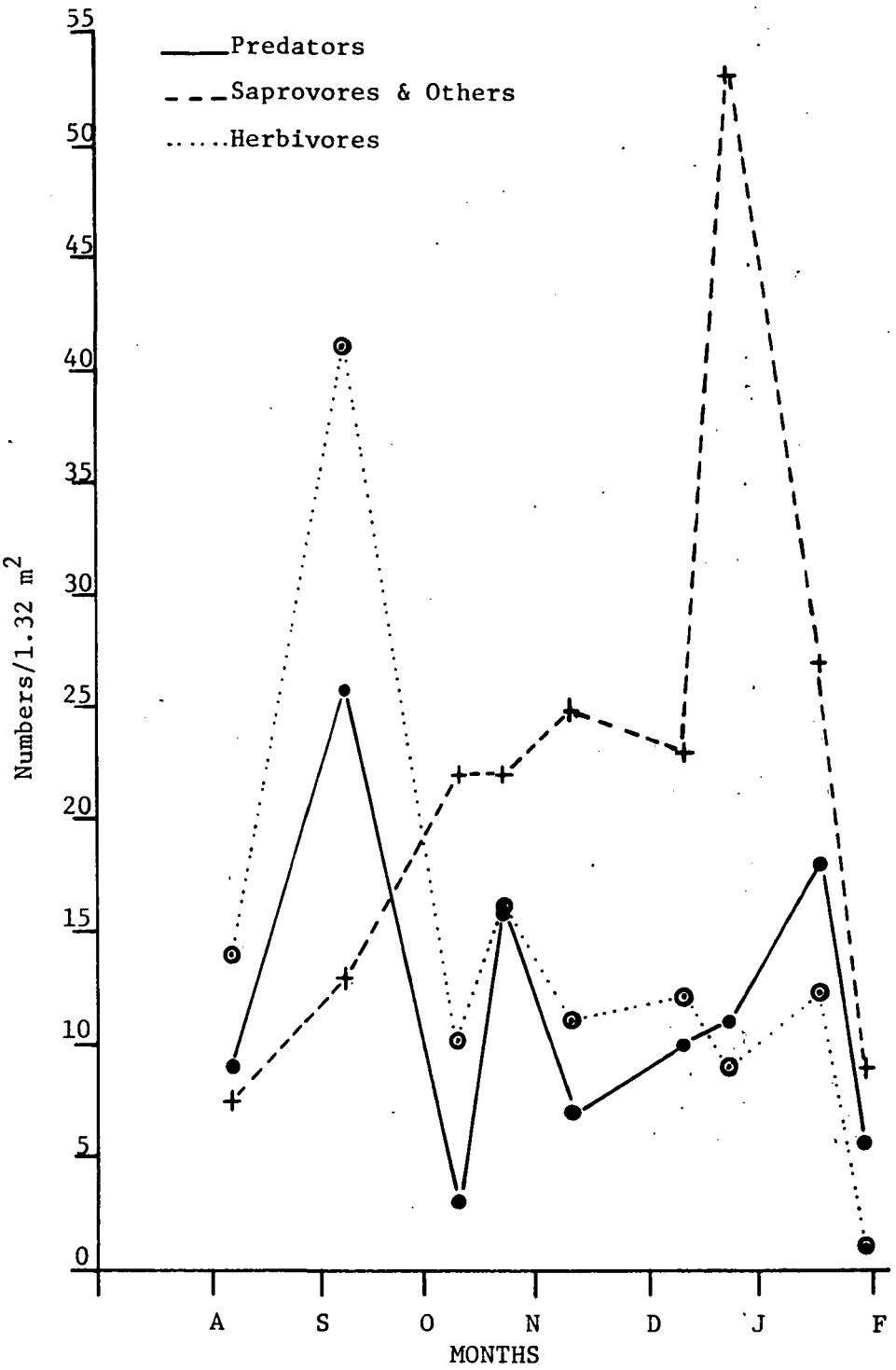


Fig. 22. Numbers of foliage macroinvertebrates for each of the trophic levels collected from the DS area on a Merritt Island, Florida salt marsh between August, 1974 and February, 1975. Numbers are for an area of 1.32 m^2; to obtain numbers/m^2 multiply by 0.758.

Fig. 23. Trophic level and overall Shannon-Weaver index of diversity for the soil macroinvertebrates collected from the SPD area of a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

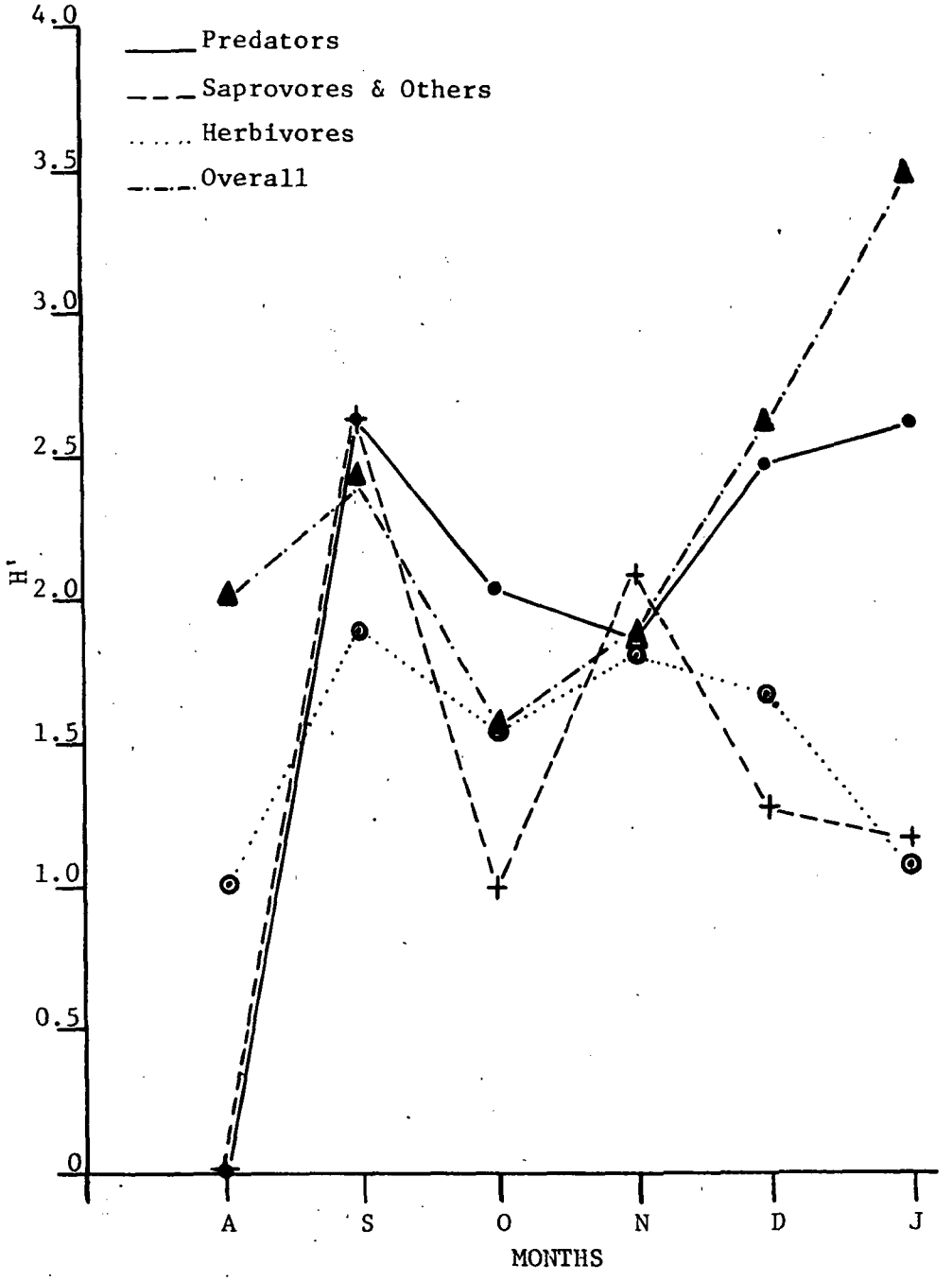


Fig. 24. Trophic level and overall Shannon-Weaver index of diversity for the soil macroinvertebrates collected from the DS area of a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

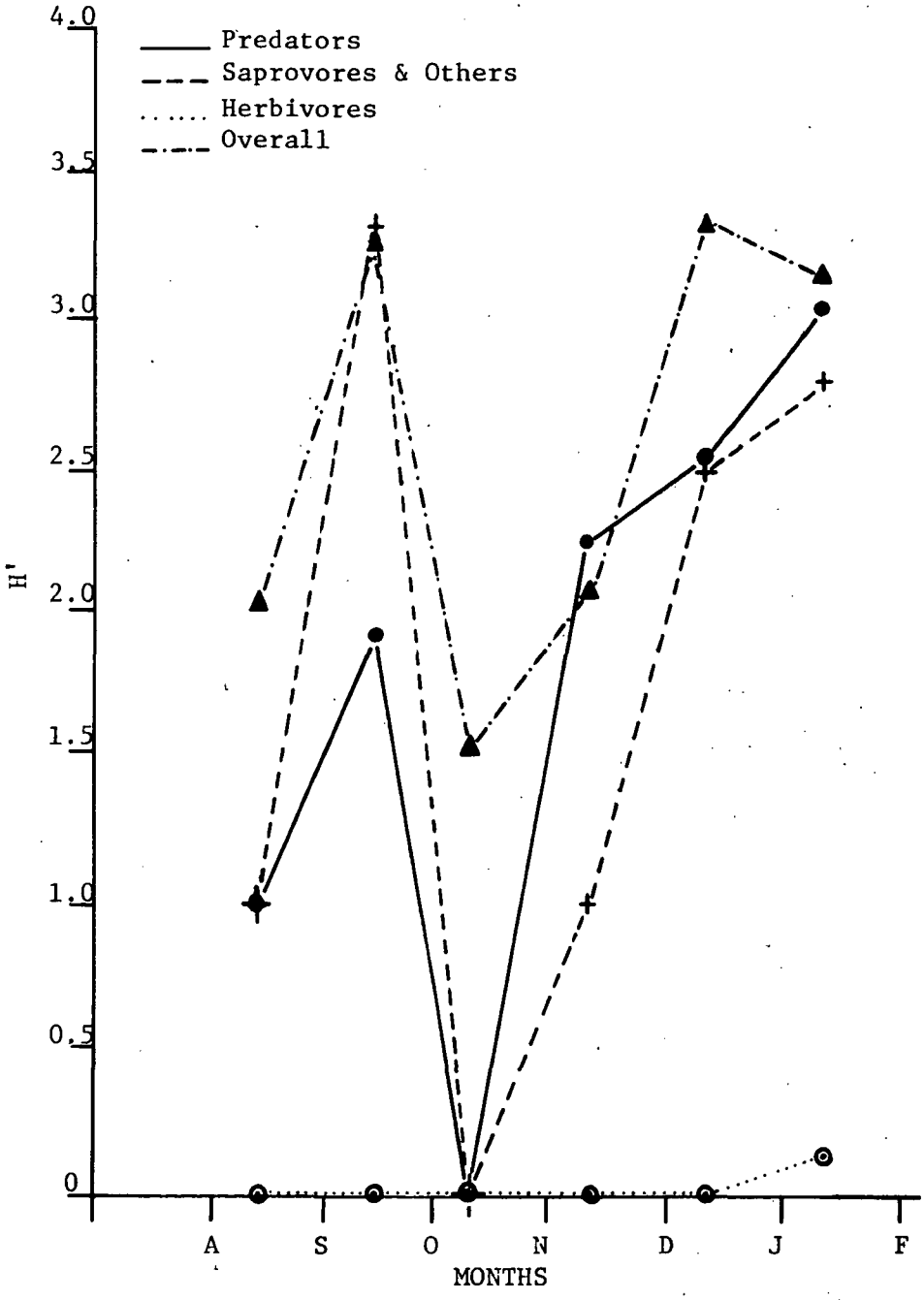


Fig. 25. Trophic level and overall dominance as measured by the Simpson's index for the soil macroinvertebrates collected from the SPD area of a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

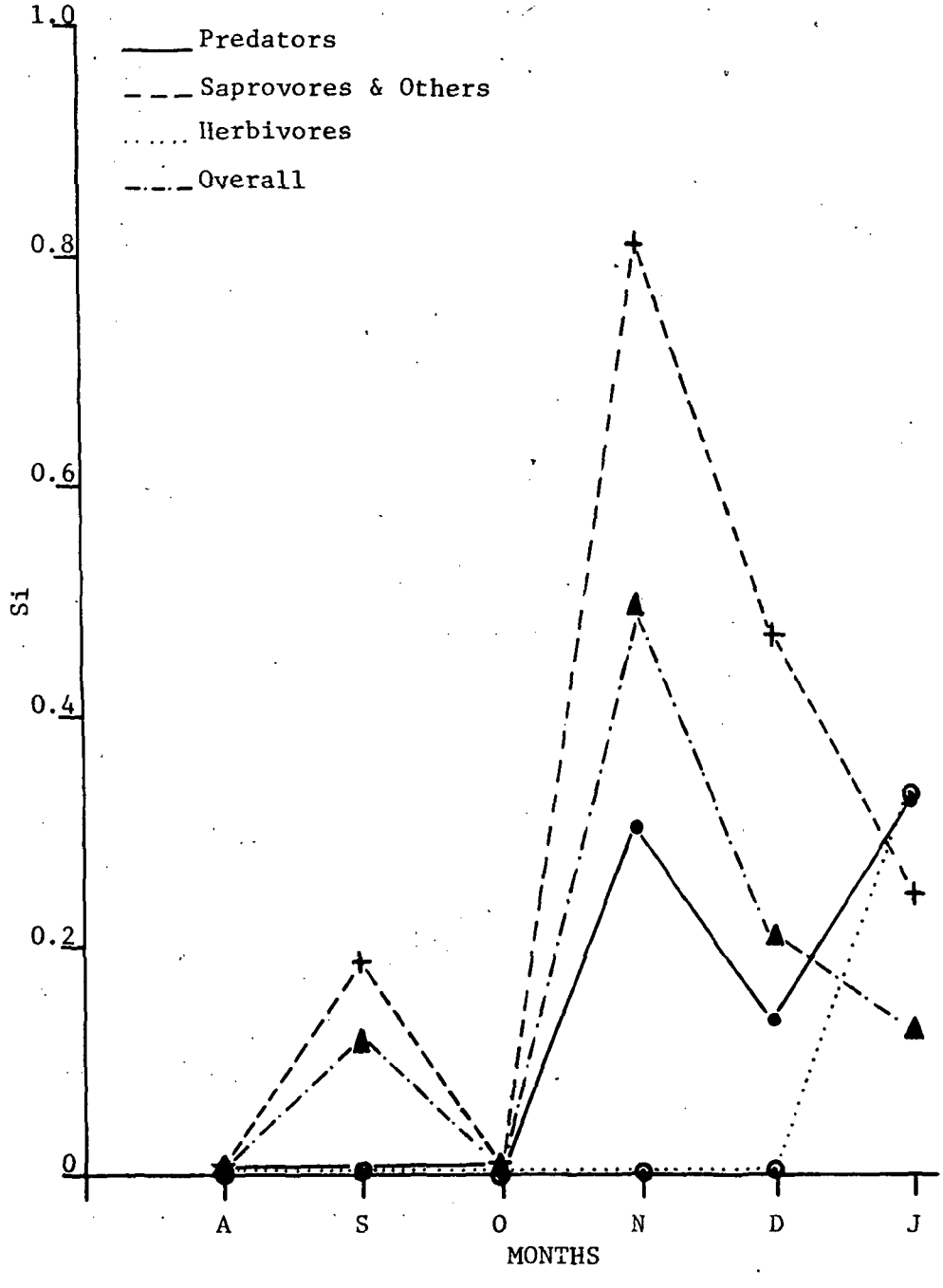
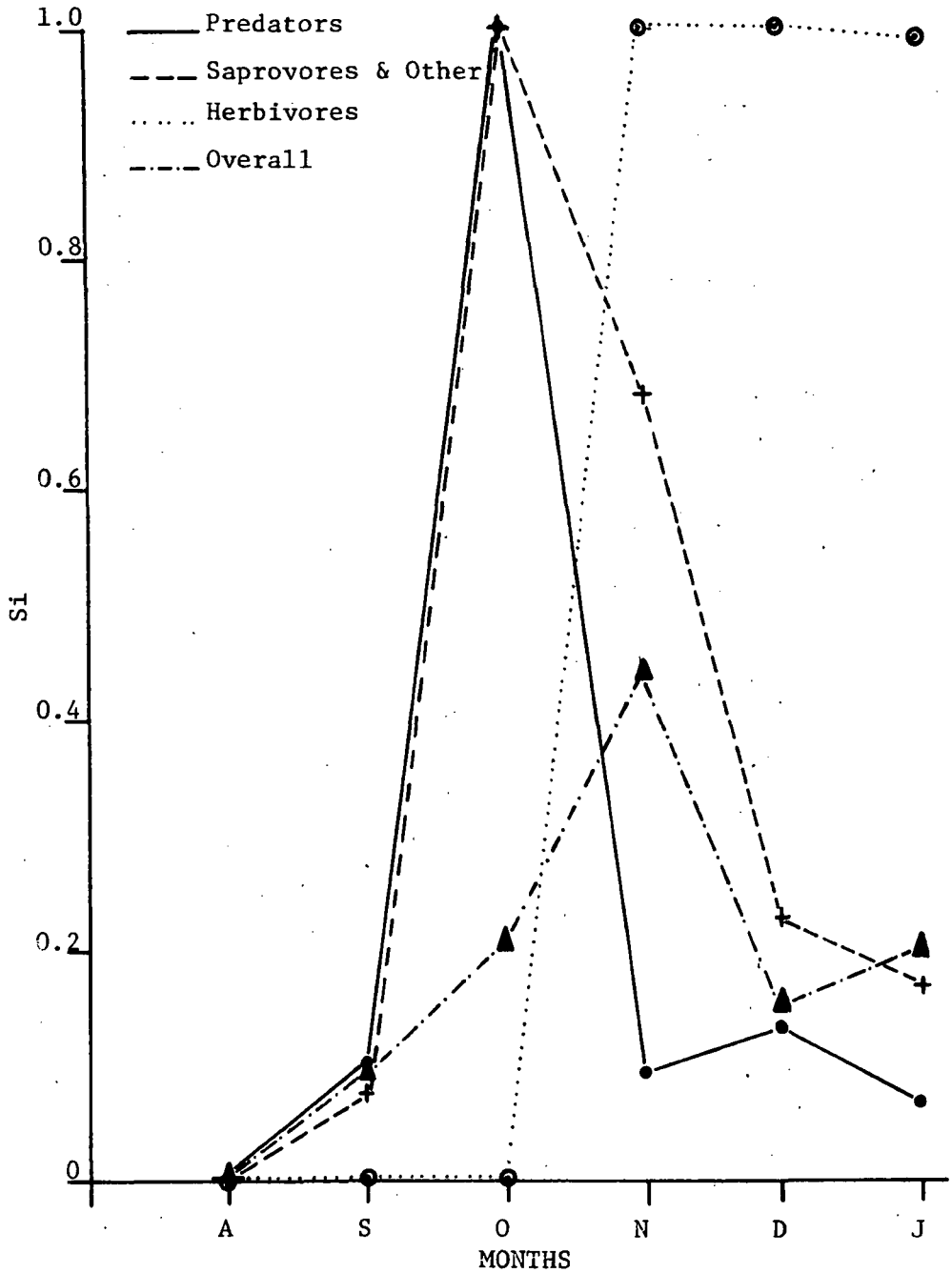


Fig. 26. Trophic level and overall dominance as measured by Simpson's index for the soil macroinvertebrates collected from the DS area of a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.



Dominance among invertebrates on the SPD area was not disproportionate in any month. A high value (Si=0.5) in November, 1974 was produced by saprovore increases and concomitant responses by the predators to their resource base. Dominance was never concentrated among the herbivores, and the highest index was reported in the final month of the study (Si=0.26 in January).

Dominance among the soil organisms in the DS area was most concentrated in November (Fig. 26), mainly owing to saprovores. Saprovore and predator dominance peaked during October (Si=1.0); however, herbivores did not peak until November. Additional statistics on species diversity of soil macroinvertebrates are summarized in Appendices I, III, V, and VII.

Diversity of Foliage Macroinvertebrates

Species diversity of foliage macroinvertebrates on the SPD area was highly variable in terms of the overall collections and the individual trophic levels (Fig. 27). Predators appeared to become more diverse after the October sample period; however, the other feeding groups continued to oscillate. Herbivores and saprovores tended to show correlated changes in diversity.

The expression of dominance within trophic levels for the SPD area was most evident among saprovores (Fig. 28). Otherwise monthly estimates of Si did not exceed 0.5 and generally were in the range 0.2-0.3.

With regard to the DS area, overall species diversity of foliage invertebrates was less variable than reported for the SPD area (Fig. 29). Diversity averaged approximately 3.0. At the individual trophic

Fig. 27. Trophic level and overall Shannon-Weaver index of diversity for the foliage macroinvertebrates collected from the SPD area of a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

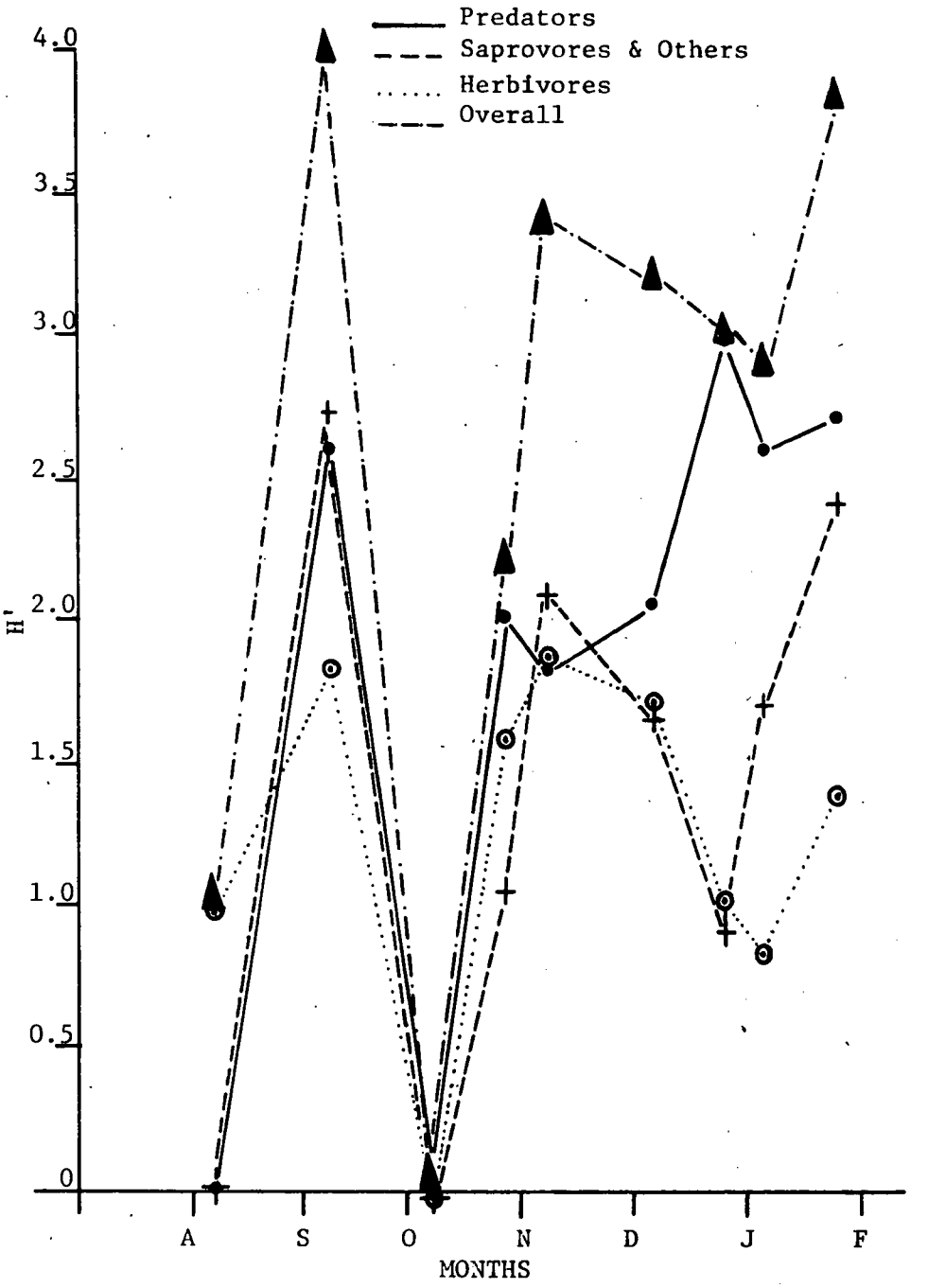
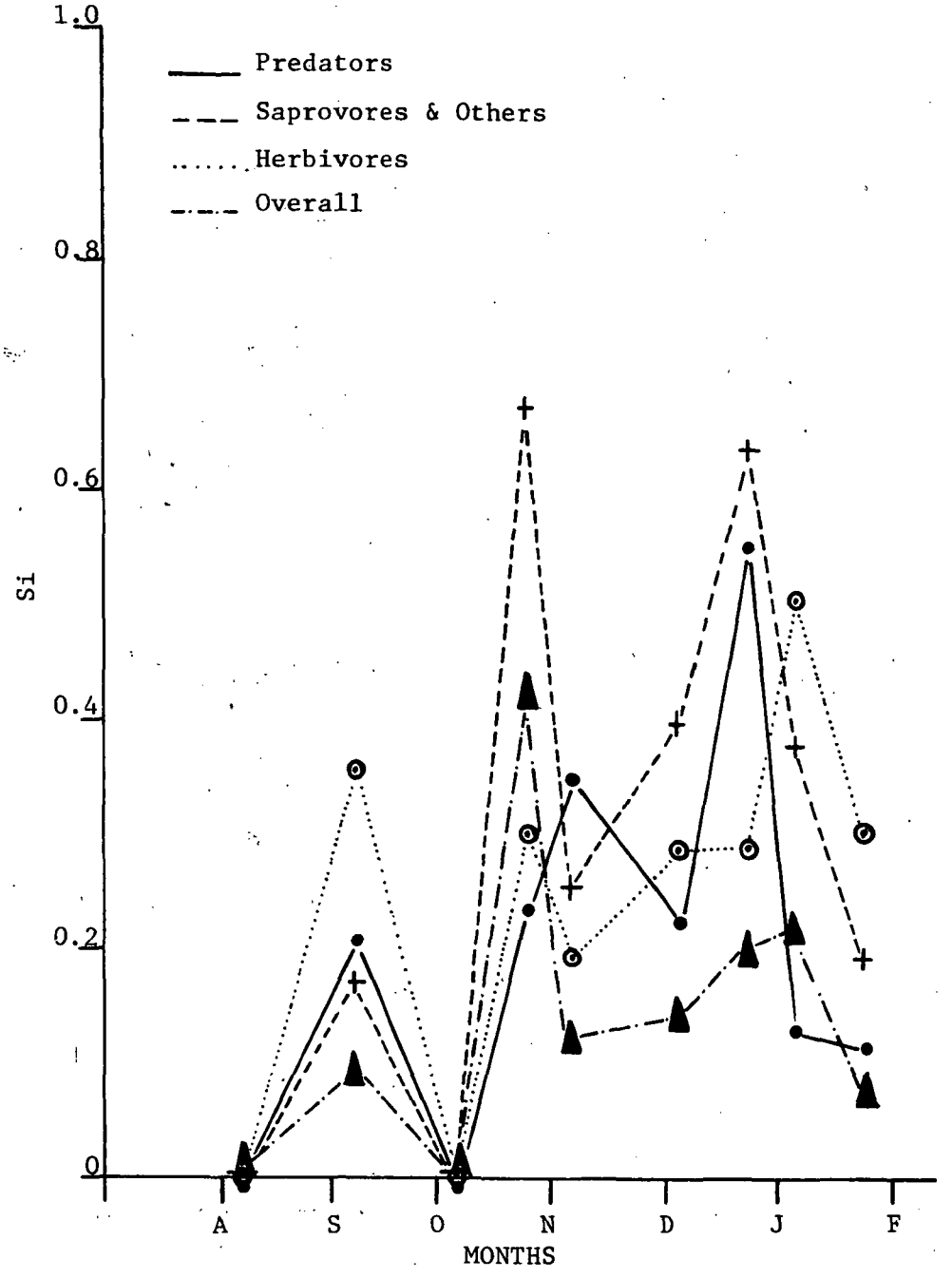


Fig. 28. Monthly estimates of dominance among foliage macroinvertebrates as measured by Simpson's index. Collections were from the SPD area of a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.



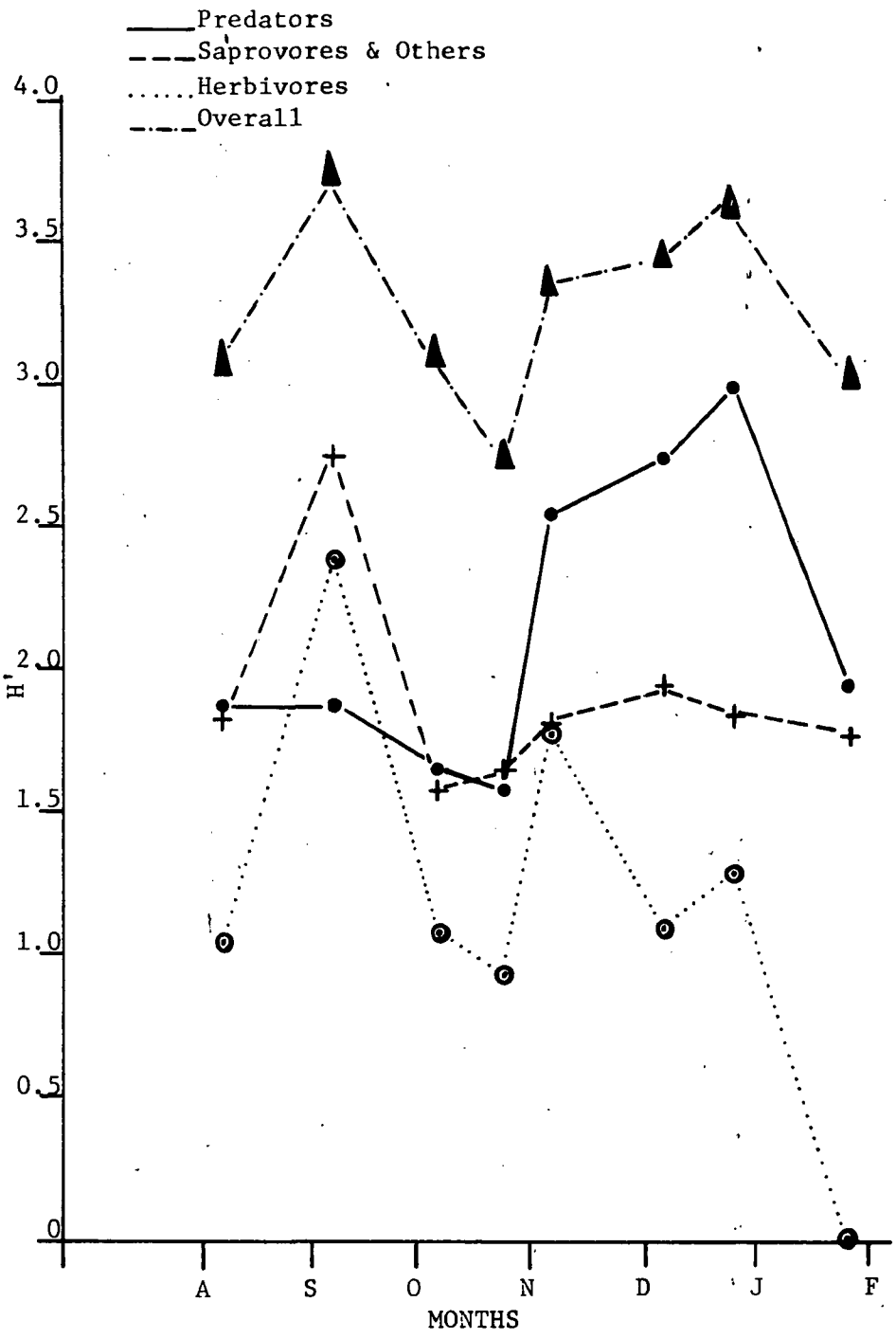


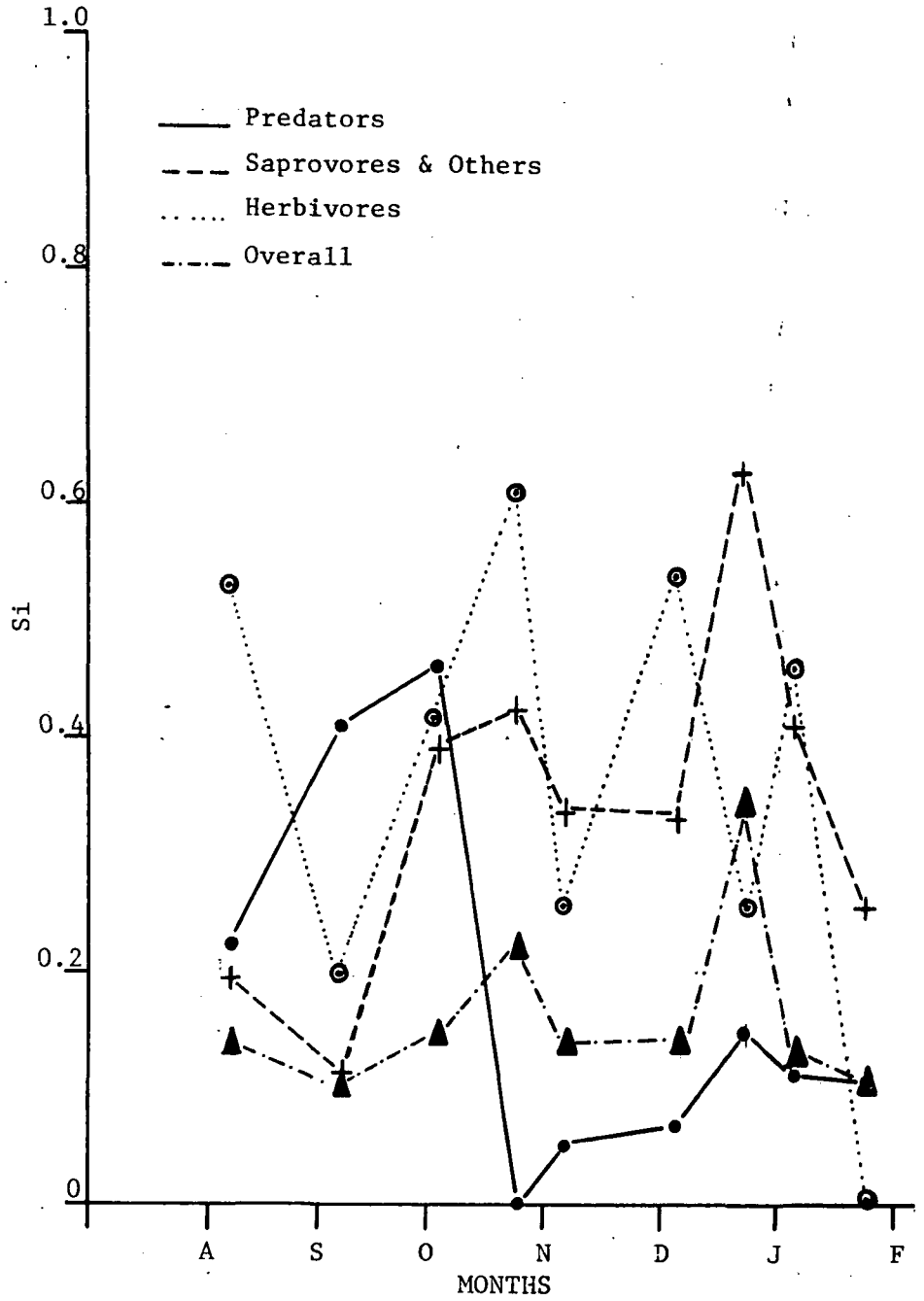
Fig. 29. Trophic level and overall Shannon-Weaver index of diversity for the foliage macroinvertebrates collected from the DS area of a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

level, however, more variation among sample periods was apparent. Herbivores diversity was extremely low throughout the period of study and fluctuated around 1.5. Predators were high in diversity during the entire 6-month period. In a similar study by Cameron (1972), he reported the opposite result for a Salicornia community similar to the DS area.

Dominance within the trophic levels was variable on the SPD area (Fig. 30). For example, among predators Si=.22 in August, 0.0 in November, and 0.1 in January. Herbivore dominance showed a regular oscillation from August until December, but diminished in January (Si=0.0).

Additional statistics on the diversity of the collections is found in Appendices I - VIII.

Fig. 30. Monthly estimates of dominance among foliage macroinvertebrates as measured by Simpson's index. Collections were from the DS area of a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.



Data Analysis

Net Primary Productivity, Caloric Content and Physical Factors

Net primary production and caloric content of Spartina, Distichilis and Sesuvium were not significantly correlated ($p < 0.05$) with rainfall (Table 17), maximum, minimum, or mean temperature (Tables 18, 19, and 20), or hours of sunlight per day (Table 21). Lack of correlation of production and rainfall might be considered puzzling in terrestrial ecosystems; however, Good (1965), Miller and Egler (1950), and Redfield (1972) have pointed out productivity in salt marshes is dependent upon soil nutrient conditions and tidal factors. Rainfall might also be expected to be inversely correlated with caloric content of marsh plants owing to leaching. Singh and Yadava (1973) have reported such an inverse relationship in the case of Indian grassland vegetation.

There were no strong correlations between productivity and mean temperature ($r = -0.101$–0.483). Mild Florida weather probably was the reason for this (Table 2). In more northern states temperature is a more critical factor in relation to production owing to the extreme seasonal changes. Examples of lower season NPP values for Spartina sp. and other marsh plants during the cooler months in northern communities is presented by Keefe (1972).

Caloric content of Distichilis from the DS area on a dry weight and AFDW basis had high negative correlation ($r = -0.811$ and -0.816) with respect to mean temperature. High caloric content was evident during

Table 17. Linear regression values for rainfall versus biological factors are given for a Merritt Island, Florida salt marsh. Calculations were taken from data gathered for the period between February, 1974 and February, 1975.

Biol. Factor	Species	r-value	N	Y-intercept	Slope
Production '1'	Spartina	0.095	6	4.522	0.005
Production '1'	Distichilis	0.322	4	1.472	0.006
Production '1'	Sesuvium	-0.522	4	10.504	-0.014
Production '2'	Spartina	0.207	7	4.812	0.006
Production '2'	Distichilis	0.057	6	4.859	0.002
Production '2'	Sesuvium	-0.234	5	8.717	-0.010
Calories/g	Spartina	-0.306	10	17.366	-0.003
Calories/g	Distichilis	-0.328	12	14.435	-0.003
Calories/g	Sesuvium	-0.109	12	9.685	-0.001
Calories/AFDW	Spartina	-0.300	10	17.314	-0.003
Calories/AFDW	Distichilis	-0.420	12	17.159	-0.003
Calories/AFDW	Seusuvium	-0.088	12	8.476	-0.001

Table 18. Linear regression values for maximum temperature versus biological factors are given for a Merritt Island, Florida salt marsh. Calculations were taken from data gathered for the period between February, 1974 and February, 1975.

Biol. Factor	Species	r-value	N	Y-intercept	Slope
Production '1'	Spartina	0.587	6	79.148	0.029
Production '1'	Distichilis	0.124	4	80.635	0.007
Production '1'	Sesuvium	0.060	4	84.120	0.002
Production '2'	Spartina	0.273	7	81.435	0.009
Production '2'	Distichilis	0.174	6	82.418	0.004
Production '2'	Sesuvium	0.123	5	82.763	0.005
Calories/g	Spartina	-0.329	10	100.307	-0.005
Calories/g	Distichilis	-0.408	12	99.179	-0.006
Calories/g	Sesuvium	-0.364	12	107.874	-0.007
Calories/AFDW	Spartina	-0.276	10	97.480	-0.004
Calories/AFDW	Distichilis	-0.418	12	99.410	-0.004
Calories/AFDW	Sesuvium	-0.347	12	105.922	-0.006

Table 19. Linear regression values for minimum temperature versus biological factors are given for a Merritt Island, Florida salt marsh. Calculations were taken from data gathered for the period between February, 1974 and February, 1975.

Biol Factor	Species	r-value	N	Y-intercept	Slope
Production '1'	Spartina	0.660	6	62.356	0.046
Production '1'	Distichilis	0.163	4	65.067	0.012
Production '1'	Sesuvium	0.369	4	70.157	0.010
Production '2'	Spartina	0.277	7	66.846	0.011
Production '2'	Distichilis	0.209	6	66.231	0.007
Production '2'	Sesuvium	0.259	5	67.308	0.016
Calories/g	Spartina	-0.183	10	80.120	-0.003
Calories/g	Distichilis	0.475	8	15.376	0.014
Calories/g	Sesuvium	-0.311	12	84.197	-0.006
Calories/AFDW	Spartina	-0.136	10	76.705	-0.002
Calories/AFDW	Distichilis	0.257	8	36.767	0.004
Calories/AFDW	Sesuvium	-0.377	12	88.149	-0.005

Table 20. Linear regression values for mean temperature versus biological factors are given for a Merritt Island, Florida salt marsh. Calculations were taken from data gathered for the period between February, 1974 and February, 1975.

Biol Factor	Species	r-value	N	Y-intercept	Slope
Production '1'	Spartina	0.355	12	-382.118	14.060
Production '1'	Distichilis	0.381	12	-83.739	3.364
Production '1'	Sesuvium	0.103	12	-63.374	2.264
Production '2'	Spartina	0.463	12	-801.793	31.555
Production '2'	Distichilis	0.483	12	-322.018	12.964
Calories/g	Spartina	-0.597	12	4799.021	-30.313
Calories/g	Distichilis	-0.811	12	6090.207	-70.834
Calories/g	Sesuvium	-0.100	12	3551.394	-5.955
Calories/AFDW	Spartina	-0.599	12	5122.532	-32.612
Calories/AFDW	Distichilis	0.274	12	2426.08	61.960
Calories/AFDW	Sesuvium	-0.130	12	5452.660	-10.910

Table 21. Linear regression values for mean daylength per month versus biological factors are given for a Merritt Island, Florida salt marsh. Calculations were taken from data gathered for the period between February, 1974 and February, 1975.

Biol. Factor	Species	r-value	N	Y-intercept	Slope
Production '1'	Spartina	-0.050	6	12.826	-0.001
Production '1'	Distichilis	0.247	4	12.102	0.003
Production '1'	Sesuvium	-0.168	4	13.208	-0.002
Production '2'	Spartina	-0.038	7	12.601	0.000
Production '2'	Distichilis	0.542	6	12.681	0.002
Production '2'	Sesuvium	-0.112	5	13.101	-0.001
Calories/g	Spartina	-0.756	10	21.883	-0.002
Calories/g	Distichilis	-0.674	12	18.850	-0.002
Calories/g	Sesuvium	-0.597	12	21.778	-0.002
Calories/AFDW	Spartina	-0.719	10	21.588	-0.002
Calories/AFDW	Distichilis	-0.572	12	17.788	-0.001
Calories/AFDW	Sesuvium	-0.575	12	21.198	-0.002

the latter months of the growing season. Seasonal changes in temperature and sunlight have been implicated in caloric content variation by Golley (1961) and Keefe (1972). Singh and Yadava (1973) found a 800-900 calorie difference between seasons in their tropical Indian grassland vegetation. Highest caloric content was found in the later, cooler months of the growing season. Forty-two percent of the variation was explained as a result of a combination of solar radiation, temperature and humidity.

A lack of strong correlation between productivity and hours of sunlight suggest day length was not a good prediction of photosynthesis in the salt marsh. Field measurements of direct solar radiation would likely reveal more directly the relationship between light and production. Correlations between hours of sunlight and caloric values were more suggestive of cause and effect (Table 21). For example, the caloric value of Spartina appeared to diminish during long days ($r= -0.76$).

Macroinvertebrates

Weak correlations were obtained between physical parameters, SCB estimates and overall species diversity (H') and dominance (Si) values of macroinvertebrates (Tables 22, 23, 24, 25). Many correlations were negative. This was the case with soil and foliage macroinvertebrates. The only significant relationship appeared to be for the SPD area in which standing crop of Sesuvium was highly correlated ($r= 0.93$, $p< 0.05$) with dominance of foliage macroinvertebrates (Table 24). In contrast with these findings Cameron (1972) found that there was a positive

Table 22. Linear regression values for species diversity (H') and dominance (Si) of soil macroinvertebrates versus physical and biological parameters are given for a Merritt Island, Florida salt marsh. Calculations were taken from data gathered for the period between August, 1974 and February, 1975. Organisms were from the SPD area.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Maximum Temperature	-0.201	4	4.005	-0.018
Minimum Temperature	-0.258	4	3.707	-0.018
Average Rainfall	-0.169	4	2.723	-0.061
Daylength	-0.243	4	4.597	-0.182
Standing Crop Biomass				
Spartina	-0.207	4	3.268	-0.001
Distichilis	-0.608	4	3.313	-0.007
Sesuvium	0.661	3	2.103	0.038

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Maximum Temperature	-0.435	4	1.044	-0.010
Minimum Temperature	-0.399	4	0.698	-0.007
Average Rainfall	-0.491	4	0.353	-0.046
Daylength	-0.441	4	1.192	-0.085
Standing Crop Biomass				
Spartina	-0.447	4	0.630	-0.001
Distichilis	-0.066	4	0.273	-0.000
Sesuvium	-0.006	3	0.295	0.000

Table 23. Linear regression values for species diversity (H') and dominance (Si) of soil macroinvertebrates from the DS area versus physical and biological parameters are given for a Merritt Island, Florida salt marsh. Calculations were taken from data gathered for the period between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Maximum Temperature	-0.235	6	4.574	-0.026
Minimum Temperature	-0.307	6	4.182	-0.026
Average Rainfall	-0.376	6	2.896	-0.098
Daylength	-0.300	6	4.772	-0.195
Standing Crop Biomass				
Distichilis	0.394	6	1.522	0.007
Sesuvium	-0.682	6	3.381	-0.005

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Maximum Temperature	-0.321	5	0.713	-0.006
Minimum Temperature	-0.320	5	0.514	-0.005
Average Rainfall	-0.592	5	0.318	-0.038
Daylength	-0.420	5	0.967	-0.068
Standing Crop Biomass				
Distichilis	-0.324	5	0.394	-0.001
Sesuvium	0.176	5	0.158	0.000

Table 24. Linear regression values for species diversity (H') and dominance (Si) of foliage macroinvertebrates from the SPD area versus physical and biological parameters are given for a Merritt Island, Florida salt marsh. Calculations were taken from data gathered for the period between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Maximum Temperature	-0.308	6	6.500	-0.047
Minimum Temperature	-0.347	6	5.390	-0.040
Average Rainfall	-0.739	6	3.810	-0.265
Daylength	-0.577	6	8.752	-0.515
Standing Crop Biomass				
Spartina	0.396	6	1.058	0.003
Distichilis	-0.097	6	3.063	-0.002
Sesuvium	0.154	4	2.749	00.030

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Maximum Temperature	-0.030	5	0.225	-0.001
Minimum Temperature	0.094	5	0.092	0.001
Average Rainfall	0.507	5	0.092	0.032
Daylength	0.056	5	0.081	0.009
Standing Crop Biomass				
Spartina	0.412	5	-0.074	0.000
Distichilis	-0.109	5	0.209	-0.000
Sesuvium	0.937	3	0.093	0.005

Table 25. Linear regression values for species diversity (H') and dominance (Si) of foliage macroinvertebrates from the DS area versus physical and biological parameters are given for a Merritt Island, Florida salt marsh. Calculations were taken from data gathered for the period between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Maximum Temperature	0.455	6	1.557	0.020
Minimum Temperature	0.384	6	2.329	0.013
Average Rainfall	-0.162	6	3.237	-0.017
Daylength	0.179	6	2.625	0.048
Standing Crop Biomass				
Distichilis	0.770	6	2.366	0.005
Sesuvium	-0.483	6	3.419	-0.001

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Maximum Temperature	-0.575	6	0.458	-0.004
Minimum Temperature	-0.495	6	0.311	-0.003
Average Rainfall	0.017	6	0.144	0.000
Daylength	-0.345	6	0.306	-0.014
Standing Crop Biomass				
Distichilis	-0.347	6	0.201	0.000
Sesuvium	-0.134	6	0.134	0.000

significant correlation ($r = 0.40$, $p < 0.05$) between above-ground primary production and herbivore diversity.

Foliage Macroinvertebrates

Diversity (H') of foliage predators was not correlated ($r = 0.44$) with the diversity of saprovores on the SPD area (Table 26). Likewise, dominance was not correlated between predators and saprovores.

Herbivore numbers were too low on the SPD area to permit analysis of diversity and dominance relationships.

The diversity (H') of foliage saprovores appeared to be associated ($r = 0.69$) with dead standing crop of Sesuvium, but not with Spartina or Distichilis (Table 27). On the other hand, dominance (Si) among saprovores was correlated with the dead standing crop of Distichilis ($r = 0.73$), and not with Spartina or Sesuvium.

Predator diversity (H') on the DS area was most closely correlated with saprovores ($r = 0.70$) and less so with herbivores ($r = 0.42$) (Table 28). Little of the variation in predator dominance was accounted for by changes in dominance of saprovores or herbivores.

Foliage saprovore diversity was negatively associated with dead standing crop of Distichilis ($r = -0.53$) and Sesuvium ($r = -0.34$) (Table 29). Dominance (Si) among saprovores was not significantly correlated with dead standing crop of the plants.

Diversity of herbivores on the DS area was significantly correlated ($r = 0.90$, $p < 0.05$) with the standing crop of living Distichilis (Table 30). Herbivore diversity was inversely related to standing crop of Sesuvium, but the association was not significant

Table 26. Linear regression values for species diversity (H') and dominance (Si) of foliage predators from the SPD area versus resource bases are given. Calculations were taken from data gathered from a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Saprovores	0.533	5	0.919	0.574

B. Si

Indepedendent Variable	r-value	N	Y-intercept	Slope
Saprovores	0.448	5	0.905	0.487

Table 27. Linear regression values for species diversity (H') and dominance (Si) of foliage saprovores from the SPD area versus resource bases are given. Calculations were taken from data gathered from a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Dead Standing Crop				
Spartina	-0.244	5	2.989	-0.001
Distichilis	-0.283	5	2.032	-0.001
Sesuvium	0.696	5	1.027	0.663

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Dead Standing Crop				
Spartina	0.165	5	0.126	0.000
Distichilis	0.739	5	0.105	0.001
Sesuvium	0.341	5	0.683	0.311

Table 28. Linear regression values for species diversity (H') and dominance (Si) of foliage predators from the DS area versus resource bases are given. Calculations were taken from data gathered from a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Saprovores	0.709	6	1.834	0.332
Herbivores	0.421	6	1.887	0.247

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Saprovores	0.562	6	0.695	0.645
Herbivores	0.570	6	0.544	0.686

Table 29. Linear regression values for species diversity (H') and dominance (Si) of foliage saprovores from the DS area versus resource bases are given. Calculations were taken from data gathered from a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Dead Standing Crop				
Distichilis	-0.535	4	3.596	-0.004
Sesuvium	-0.340	4	3.042	-0.029

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Dead Standing Crop				
Distichilis	0.172	4	0.190	0.001
Sesuvium	0.568	4	-0.392	0.017

Table 30. Linear regression values for species diversity (H') and dominance (Si)' of foliage herbivores from the DS area versus resource bases are given. Calculations were taken from data gathered from a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Standing Crop Biomass				
Distichilis	0.907	6	-0.044	0.010
Sesuvium	-0.512	6	1.900	-0.002

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Standing Crop Biomass				
Distichilis	-0.815	6	0.817	-0.003
Sesuvium	0.496	6	0.294	0.001

(r = -0.51). Dominance (Si) of herbivores was inversely related to the standing crop of living Distichilis (r = -0.81), in contrast to the direct relationship between diversity and standing crop.

Cameron (1972) and Hurd and Wolf (1974) reported similar correlations among producer and consumer populations in their studies: In general, herbivores diversities were positively correlated with live standing crop; saprovore diversity was strongly correlated with litter accumulation; and predators were positively correlated with herbivore richness (diversity) or secondarily with live standing crop of producers.

Soil Macroinvertebrates

The species diversity (H') of soil predators was somewhat correlated with saprovore (r = .71) and herbivore (r = .60) diversity in the SPD area (Table 31). Predator dominance (Si) appeared to be weakly related to saprovore and herbivore dominance.

Saprovore diversity in the SPD area was not correlated with the standing crop of dead Spartina (r = -0.18) or Sesuvium (r = 0.37), but was significantly correlated with Distichilis ($r = -0.98$, $p < .05$) (Table 32). Dominance among saprovores was also correlated with the standing crop of dead material. The result with Distichilis was most clearly expressed in that high values of dead Distichilis were associated with low diversity (H') and high dominance (Si) among saprovores. Cameron (1972), in contrast to my findings reported a significant correlation between standing crop of dead Spartina and the diversity of soil saprovores.

Table 31. Linear regression values for species diversity (H') and dominance (Si) of soil predators of the SPD area versus their resource bases are given. Calculations were taken from data gathered from a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Saprovores	0.719	5	0.117	0.798
Herbivores	0.604	4	0.292	0.844

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Saprovores	0.354	4	0.128	0.345
Herbivores	0.414	3	0.113	0.405

Table 32. Linear regression values for species diversity (H') and dominance (Si) of soil saprovores of the SPD area versus their resource bases are given. Calculations were taken from data gathered from a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Dead Standing Crop				
Spartina	-0.182	5	2.423	-0.001
Distichilis	-0.983	5	4.133	-0.011
Sesuvium	0.372	2	0.904	0.415

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Dead Standing Crop				
Spartina	0.791	4	-1.192	0.002
Distichilis	0.840	4	-0.326	0.003
Sesuvium	0.568	4	-0.392	0.017

Herbivores in the SPD area existed at such low densities that calculation of diversity indices was not done.

In the DS area diversity of soil predators was positively correlated with saprovore diversity (r= 0.75) but not with herbivore diversity (r= 0.38) (Table 33). Dominance among the predators was not significantly correlated ($p<0.05$) with dominance of saprovores or herbivores (Table 33).

Saprovore diversity and dominance were weakly correlated with the standing crop of dead Distichilis and Sesuvium (Table 34). This result contrasts with findings for the SPD area where significant associations were demonstrated between saprovores and the biomass of dead Distichilis.

Herbivore dominance (Si) was significantly correlated with the live standing crop of Sesuvium (r= 0.94, $p<0.05$) and positively associated with Distichilis (r= 0.74) (Table 35). Whereas, the diversity (H') of herbivores was inversely correlated with live standing crop of Distichilis and Sesuvium; however, neither association was significant ($p<0.05$).

T-Test

Mean net primary production of Sesuvium portulacastrum and Distichilis spicata growing in the DS and SPD areas was not significantly different ($p<0.05$) (Table 36). Mean caloric content, however, was significantly different ($p<0.05$) on a dry weight and AFDW basis for Sesuvium portulacastrum. The lack of any significant differences between the mean values of production and caloric content of the

Table 33. Linear regression values for species diversity (H') and dominance (Si) of soil predators of the DS area versus their resource bases are given. Calculations were taken from data gathered from a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Saprovores	0.751	5	0.651	0.640
Herbivores	0.379	5	1.502	0.316

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Saprovores	0.595	6	0.223	0.837
Herbivores	0.525	5	0.217	0.718

Table 34. Linear regression values for species diversity (H') and dominance (Si) of soil saprovores of the DS area versus their resource bases are given. Calculations were taken from data gathered from a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Dead Standing Crop				
Distichilis	0.004	5	2.105	0.000
Sesuvium	0.048	5	1.940	0.004

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Dead Standing Crop				
Distichilis	0.219	5	0.032	0.001
Sesuvium	-0.276	5	0.857	-0.010

Table 35. Linear regression values for species diversity (H') and dominance (Si) of soil herbivores of the DS area versus their resource bases are given. Calculations were taken from data gathered from a Merritt Island, Florida salt marsh between August, 1974 and February, 1975.

A. H'

Independent Variable	r-value	N	Y-intercept	Slope
Standing Crop Biomass				
Distichilis	-0.473	6	0.825	-0.004
Sesuvium	-0.488	6	0.731	-0.003

B. Si

Independent Variable	r-value	N	Y-intercept	Slope
Standing Crop Biomass				
Distichilis	0.744	3	0.809	0.001
Sesuvium	0.946	3	0.890	0.001

Table 36. Student T-test values calculated for net primary production and caloric content of identical species of plants in the SPD and DS communities of a Merritt Island, Florida salt marsh.

Variable	Degrees of Freedom	Distichilis	Degrees of Freedom	Sesuvium
Production '1'	20	0.040 (1.725[a])	20	0.120 (1.725)
Production '2'	20	-0.980 (1.725)	20	-0.003 (1.725)
Calories/g	20	0.732 (1.725)	18	3.108 (1.729[b])
Calories/AFDW	20	-0.685 (1.725)	18	4.977 (1.729[b])

[a]Student-t values from Steele and Torrey (1960).
[b]These values were found to be significant ($p<0.05$).

plants except for Sesuvium indicates that the two areas (SPD and DS) were probably very similar in growing conditions. Observed differences in caloric content and not in production may indicate there was consumption and storage of one or a few non-volatile substances which did not affect production, but did affect caloric content by increasing ash content or specific heat of the plants.

Summary

Studies on vascular plants and associated macroinvertebrates were conducted on a Merritt Island, Florida salt marsh to describe its structure and function. Estimates were made of standing crop biomass (SCB), net primary production (NPP), caloric content of plants, and species diversity of macroinvertebrates.

Five major plant cover types were recognized on the study area including two grassy areas, Juncus islands, and wet and dry prairie. Sixty percent of the marsh was covered by vegetation dominated by salt marsh grasses. The plant communities investigated were designated as the SPD area, dominated by Spartina bakerii, and the DS area dominated by Distichilis spicata and Sesuvium portulacastrum.

Net primary production was estimated from standing crop biomass utilizing the short-term harvest method. Estimates of NPP ranged from 707.85 to 1,521.29 $g \cdot m^{-2} \cdot yr^{-1}$ for Spartina bakerii, 191.36 to 569.65 $g \cdot m^{-2} \cdot yr^{-1}$ for Sesuvium portulacastrum, and 234.77 to 1,506.07 for Distichilis spicata. These values compared favorably with published data on similar species of plants.

Two peak periods of net primary production occurred on the study areas. Net primary production of S. bakerii peaked during the intervals June-July and August-September, 1974. Distichilis spicata from the SPD area peaked in June-July and September-October, while on the DS area it peaked during March-April and May-June. Sesuvium portulacastrum had its highest NPP manifested in February-March and April-May.

Living standing crop biomass reached a maximum once or twice during the study period depending on the species. On the SPD area, S. bakerii attained high SCB in February, 1974 with a lesser increase appearing in September and October. Maximum SCB was reached in September for D. spicata, whereas Sesuvium portulacastrum's peak was attained in March, 1974.

D. spicata from the DS area had a high SCB in August, 1974. In contrast, Sesuvium portulacastrum peaked in April and May, 1974 on the same area.

Caloric content of the marsh plants studied was found to vary seasonally. Greatest caloric values were determined during late fall and early winter. Average annual caloric values on an ash-free dry weight basis for the species were: Spartina bakerii (4362.10); Distichilis spicata (4350.57); and Sesuvium portulacastrum (6439.42). Seasonal variation in caloric content was observed to be most pronounced among plants from the DS area. Further, caloric values for Sesuvium from the DS and SPD areas were significantly different ($p < 0.05$).

Mean ash content of the species was: Sesuvium (27%); Distichilis (5%); and Spartina (6%).

Field observations revealed the periods of flowering of the plants overlapped somewhat. Spartina bakerii flowered between December and February, whereas Distichilis spicata began sexual reproduction in late July and continued until early September. Sesuvium portulacastrum was found to flower almost continually during the year, but began its major reproductive effort in March and continued until May.

A vacuum sampler and soil auger were used to collect macroin-

vertebrates objectively from foliage and soil strata of the SPD and DS areas. Calculation of the Shannon-Weaver index of species diversity (H'), the Simpson's index of dominance (Si), as well as Redundancy, and Equitability followed identification of invertebrates to the family level. Seventy-nine families representing 18 different invertebrate orders were collected.

In soil samples, saprovore groups were preponderant. Saprovore numbers were the most dynamic among the feeding groups throughout the 6-month sample period. Saprovore numbers increased significantly during the period of October through December in response to increases in standing dead plant biomass on both study areas.

Predator populations closely followed and mimicked fluctuations in saprovore numbers for some SPD populations.

Soil herbivores were not common and numbers remained low (near zero) until the very last of the year.

Foliage invertebrate numbers were similar to those determined for soil invertebrates. Saprovores were the most numerous and dynamic of the feeding types. Peak numbers of saprovores were reached in October on the SPD area and in December on the DS area. Changes in predator and herbivore densities were closely associated with the saprovores in this stratum.

Overall species diversity (H') of the SPD soil invertebrates reached a maximum in December (3.4) while peak dominance (Si) was manifested in November, 1974 (0.5). Overall soil invertebrate diversity also peaked in December (3.3) on the DS area.

Diversity of foliage macroinvertebrates on the SPD area was

highly variable in terms of overall numbers and trophic levels. Predators were more diverse after October, while other feeding groups continued to oscillate. Herbivores and saprovores appeared to have correlated changes in diversity. Saprovores attained highest dominance beginning in October.

Overall species diversity of foliage invertebrates from the DS area was less variable than for the SPD area. Values averaged approximately 3.0. Herbivores had extremely low species diversity while predator diversity was high throughout the 6-month study. Dominance was low for predators whereas herbivore values were relatively high (Si ranged from 0.2 to 0.6).

Regression analysis indicated very low correlation values between physical parameters and biological factors. Exceptions were caloric content (dry weight and AFDW) versus daylength ($r = -0.74$). Some very high correlations were found between individual trophic groups and their resource bases.

On the SPD area soil saprovore dominance (Si) was strongly correlated with standing dead biomass of Distichilis ($r = 0.84$) and Spartina ($r = 0.79$). The species diversity of saprovores on the SPD area was significantly correlated ($r = 0.98$, $p < 0.05$) with the standing crop of dead Sesuvium. Likewise, diversity of foliage saprovores was correlated ($r = 0.74$) with the standing crop of dead of Distichilis.

Foliage invertebrates from the DS area showed similar relationships to those reported for the SPD area. Herbivore diversity was highly correlated with the standing crop of Distichilis ($r = 0.90$). On the other hand, predator diversity showed a positive correlation

Appendix I

Summary of calculations of diversity and dominance indices for the overall collection of soil organisms. Collections were from a Merritt Island, Florida salt marsh during the period August, 1974 to February, 1975. The number of species and number of organisms collected on each date is given.

Area	Date	No. Organisms	No. Species	Simpson's	Shannon-Weaver	Redundancy	Equitability
SPD	8-19-74	0	0	0.000	0.000	0.000	0.000
SPD	9-15-74	9	6	0.111	2.419	0.545	0.936
SPD	10-23-74	0	0	0.000	0.000	0.000	0.000
SPD	11-08-74	94	14	0.492	1.810	0.735	0.475
SPD	12-23-74	115	18	0.283	2.641	0.516	0.633
SPD	1-25-75	89	18	0.122	3.483	0.255	0.835
DS	8-19-74	4	4	0.000	2.000	0.000	1.000
DS	9-15-74	20	12	0.090	3.241	0.498	0.904
DS	10-23-74	5	3	0.200	1.522	0.295	0.960
DS	11-08-74	50	11	0.438	2.004	0.702	0.579
DS	12-23-74	65	18	0.145	3.302	0.382	0.792
DS	1-25-75	126	21	0.195	3.122	0.413	0.711

Appendix II

Summary of calculations of diversity and dominance indices for the overall collection of foliage organisms. Collections were from a Merritt Island, Florida salt marsh during the period August, 1974 to February, 1975. The number of species and number of organisms collected on each date is given.

Area	Date	No. Organisms	No. Species	Simpson's	Shannon-Weaver	Redundancy	Equitability
SPD	8-19-74	2	2	0.000	1.000	0.000	1.000
SPD	9-15-74	92	25	0.081	3.972	0.257	0.855
SPD	10-10-74	0	0	0.000	0.000	0.000	0.000
SPD	10-23-74	157	14	0.410	2.176	0.528	0.572
SPD	11-08-74	57	16	0.113	3.364	0.297	0.841
SPD	12-03-74	40	14	0.132	3.241	0.334	0.851
SPD	12-19-74	28	13	0.185	2.985	0.607	0.807
SPD	1-16-75	64	16	0.208	2.865	0.494	0.716
SPD	1-25-75	35	18	0.064	3.817	0.297	0.915
DS	8-19-74	30	11	0.138	3.016	0.309	0.872
DS	9-15-74	81	21	0.095	3.714	0.269	0.855
DS	10-10-74	51	13	0.139	3.066	0.306	0.829
DS	10-23-74	35	12	0.210	2.692	0.558	0.751
DS	11-08-74	43	16	0.127	3.295	0.414	0.824
DS	12-03-74	48	17	0.125	3.364	0.394	0.823
DS	12-19-74	72	14	0.329	2.408	0.569	0.632
DS	1-16-75	57	20	0.119	3.568	0.379	0.826
DS	1-25-75	15	9	0.095	2.923	0.430	0.922

Appendix III

Summary of calculations of diversity and dominance indices for the soil predators. Collections were from a Merritt Island, Florida salt marsh during the period August, 1974 to February, 1975. The number of species and number of organisms collected on each date is given.

Area	Date	No. Organisms	No. Species	Simpson's	Shannon-Weaver	Redundancy	Equitability
SPD	8-19-74	0	0	0.000	0.000	0.000	0.000
SPD	9-15-74	2	2	0.000	1.000	0.000	1.000
SPD	10-23-74	0	0	0.000	0.000	0.000	0.000
SPD	11-08-74	22	8	0.303	2.197	0.667	0.732
SPD	12-23-74	25	9	0.137	2.803	0.281	0.884
SPD	1-23-75	49	7	0.325	2.060	0.382	0.734
DS	8-19-74	2	2	0.000	1.000	0.000	1.000
DS	9-15-74	5	4	0.100	0.922	1.000	0.961
DS	10-23-74	2	1	1.000	0.000	0.000	1.000
DS	11-08-74	7	5	0.095	2.236	0.444	0.963
DS	12-23-74	12	7	0.136	2.522	0.554	0.898
DS	1-23-75	14	9	0.066	3.039	0.278	0.959

Appendix IV

Summary of calculations of diversity and dominance indices for the foliage predators. Collections were from a Merritt Island, Florida salt marsh during the period August, 1974 to February, 1975. The number of species and number of organisms collected on each date is given.

Area	Date	No. Organisms	No. Species	Simpson's	Shannon-Weaver	Redundancy	Equitability
SPD	8-19-74	0	0	0.000	0.000	0.000	0.000
SPD	9-15-74	23	10	0.206	2.645	0.607	0.796
SPD	10-10-74	0	0	0.000	0.000	0.000	0.000
SPD	10-23-74	20	5	0.237	2.041	0.234	0.879
SPD	11-08-74	20	6	0.342	1.840	0.625	0.711
SPD	12-03-74	12	5	0.212	2.055	0.363	0.885
SPD	12-19-74	11	8	0.546	2.914	0.321	0.971
SPD	1-16-75	13	7	0.128	2.565	0.391	0.914
SPD	1-25-75	13	8	0.115	2.719	0.570	0.906
DS	8-19-74	9	4	0.222	1.836	0.295	0.918
DS	9-15-74	27	7	0.402	1.857	0.647	0.662
DS	10-10-74	16	6	0.458	1.622	1.000	0.627
DS	10-23-74	3	3	0.000	1.585	0.000	1.000
DS	11-08-74	7	6	0.047	2.522	1.000	0.976
DS	12-03-74	10	7	0.067	2.722	0.299	0.970
DS	12-19-74	11	6	0.145	2.369	0.404	0.916
DS	1-16-75	18	10	0.111	2.969	0.478	0.893
DS	1-25-75	5	4	0.100	1.922	1.000	0.961

Appendix V

Summary of calculations of diversity and dominance indices for the soil saprovores. Collections were from a Merritt Island, Florida salt marsh during the period August, 1974 to February, 1975. The number of species and number of organisms collected on each date is given.

Area	Date	No. Organisms	No. Species	Simpson's	Shannon-Weaver	Redundancy	Equitability
SPD	8-19-74	0	0	0.000	0.000	0.000	0.000
SPD	9-15-74	7	4	0.191	1.842	0.469	0.921
SPD	10-23-74	1	1	0.000	0.000	0.000	0.000
SPD	11-08-74	72	6	0.815	0.667	0.931	0.258
SPD	12-23-74	88	7	0.471	1.488	0.581	0.530
SPD	1-23-75	37	9	0.146	2.774	0.224	0.875
DS	8-19-74	2	2	0.000	1.000	0.000	1.000
DS	9-15-74	23	13	0.079	3.377	0.389	0.912
DS	10-23-74	2	1	1.000	0.000	0.000	0.000
DS	11-08-74	40	5	0.685	0.991	0.805	0.427
DS	12-23-74	51	10	0.228	2.495	0.396	0.761
DS	1-23-75	61	10	0.168	2.771	0.245	0.834

Appendix VI

Summary of calculations of diversity and dominance indices for the foliage saprovores. Collections were from a Merritt Island, Florida salt marsh during the period August, 1974 to February, 1975. The number of species and number of organisms collected on each date is given.

Area	Date	No. Organisms	No. Species	Simpson's	Shannon-Weaver	Redundancy	Equitability
SPD	8-19-74	0	0	0.000	0.000	0.000	0.000
SPD	9-15-74	37	9	0.170	2.737	0.245	0.863
SPD	10-10-74	0	0	0.000	0.000	0.000	0.000
SPD	10-23-74	122	6	0.670	1.005	0.704	0.389
SPD	11-08-74	30	6	0.255	2.097	0.315	0.811
SPD	12-03-74	21	5	0.395	1.685	0.515	0.726
SPD	12-19-74	15	3	0.638	0.906	0.768	0.571
SPD	1-16-75	47	7	0.377	1.701	0.574	0.606
SPD	1-25-75	17	7	0.191	2.417	0.408	0.861
DS	8-19-74	7	4	0.191	1.842	0.470	0.921
DS	9-15-74	13	8	0.115	2.719	0.570	0.906
DS	10-10-74	22	4	0.390	1.546	0.376	0.773
DS	10-23-74	22	6	0.420	1.672	0.710	0.647
DS	11-08-74	25	6	0.333	1.793	0.566	0.694
DS	12-03-74	23	6	0.324	1.892	0.523	0.732
DS	12-19-74	52	4	0.622	0.968	0.649	0.484
DS	1-16-75	27	7	0.407	1.811	0.678	0.645
DS	1-25-75	9	4	0.250	1.753	0.447	0.876

Appendix VII

Summary of calculations of diversity and dominance indices for the soil herbivores. Collections were from a Merritt Island, Florida salt marsh during the period August, 1974 to February, 1975. The number of species and number of organisms collected on each date is given.

Area	Date	No. Organisms	No. Species	Simpson's	Shannon-Weaver	Redundancy	Equitability
SPD	8-19-74	0	0	0.000	0.000	0.000	0.000
SPD	9-15-74	0	0	0.000	0.000	0.000	0.000
SPD	10-23-74	0	0	0.000	0.000	0.000	0.000
SPD	11-08-74	0	0	0.000	0.000	0.000	0.000
SPD	12-23-74	2	2	0.000	1.000	0.000	1.000
SPD	1-23-75	3	2	0.333	0.918	1.000	0.918
DS	8-19-74	0	0	0.000	0.000	0.000	0.000
DS	9-15-74	0	0	0.000	0.000	0.000	0.000
DS	10-23-74	0	0	0.000	0.000	0.000	0.000
DS	11-08-74	3	1	1.000	0.000	0.000	0.000
DS	12-23-74	2	1	1.000	0.000	0.000	0.000
DS	1-23-75	51	2	0.961	0.139	1.000	0.139

Appendix VIII

Summary of calculations of diversity and dominance indices for the foliage herbivores. Collections were from a Merritt Island, Florida salt marsh during the period August, 1974 to February, 1975. The number of species and number of organisms collected on each date is given.

Area	Date	No. Organisms	No. Species	Simpson's	Shannon-Weaver	Redundancy	Equitability
SPD	8-19-74	2	2	0.000	1.000	0.000	1.000
SPD	9-15-74	32	6	0.351	1.873	0.446	0.724
SPD	10-10-74	0	0	0.000	0.000	0.000	0.000
SPD	10-23-74	15	3	0.295	1.566	0.022	0.988
SPD	11-08-74	7	4	0.191	1.842	0.469	0.921
SPD	12-03-74	7	4	0.286	1.665	1.000	0.832
SPD	12-19-74	2	2	0.286	1.000	0.000	1.000
SPD	1-16-75	4	2	0.500	0.811	1.000	0.811
SPD	1-25-75	5	3	0.300	1.371	1.000	0.865
DS	8-19-74	14	3	0.528	1.095	0.576	0.691
DS	9-15-74	41	6	0.194	2.388	0.111	0.924
DS	10-10-74	13	3	0.410	1.335	0.308	0.842
DS	10-23-74	10	3	0.622	0.922	1.000	0.582
DS	11-08-74	11	4	0.254	1.790	0.291	0.895
DS	12-03-74	15	4	0.533	1.237	0.794	0.618
DS	12-19-74	9	4	0.250	1.753	0.447	0.876
DS	1-16-75	12	3	0.455	1.252	0.434	0.790
DS	1-25-75	1	1	0.000	0.000	0.000	0.000

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